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PART 2/3

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

(ANNEX 1-4)

Accompanying the document

PROPOSAL FOR A REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

on type-approval of motor vehicles and of engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7) and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009

{COM(2022) 586 final} - {SEC(2022) 397 final} - {SWD(2022) 358 final} - {SWD(2022) 360 final}

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Annex 1: Procedural information

1. Lead DG, Decide Planning/CWP references

This initiative is led by Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW).

The European Green Deal[1] announces a proposal by 2021 for more stringent air pollutant emissions standards for combustion-engine vehicles (Euro 7).

The Agenda Planning Reference is PLAN/2020/6308 for the development of Euro 7 emission standards for cars, vans, lorries and buses which is part of the Commission's 2020/2021 Work Programme.

2. Organisation and timing

The evaluation of Euro 6/VI emission standards and impact assessment for more stringent air pollutant emissions standards for combustion-engine vehicles (Euro 7) were conducted in a back-to-back approach to meet the roadmap set by the European Green Deal. That way, the findings of the evaluation which are included in Annex 5 are used to inform further reflection on whether Euro 6/VI emission standards continue to provide high level environmental protection in the EU and to ensure the proper function of the internal market for motor vehicles.

DG GROW established on 10 February 2020 and chaired the Inter-Service Steering Group for the development of Euro 7 emission standards for cars, vans, lorries and buses. The following Directorates-General (DG) participated: Secretary-General, DG Climate Action, DG Environment, DG Joint Research Centre, DG Justice and Consumers, DG Mobility and Transport, DG Research and Innovation and DG Communications Networks, Content and Technology. The following meetings took place:

1) 4 March 2020 – on the combined evaluation roadmap/inception impact assessment, consultation strategy and public consultation
2) 10 July 2020 – on the Advisory Group on Vehicle Emission Standards (AGVES) meeting of the 9 July, the first results from the Euro 6/VI evaluation and stakeholder feedback to the inception impact assessment and targeted consultation of the evaluation
3) 11 September 2020 – on the AGVES meeting of the 10 September, coherence to air quality and Euro 7 in a global picture
4) 17 December 2020 – on the AGVES meeting of the 26/27 November, stakeholder feedback to the public consultation and targeted consultation on the impact assessment, on the final results from the Euro 6/VI evaluation and the inter-service collaboration on the impact assessment
5) 7 April 2021 –on the first chapters 1-4 of the impact assessment staff working document and the first results on the emission limits from the studies
6) 3 June 2021 – on the full impact assessment staff working document
7) 18 November 2021 – on the revised impact assessment staff working document following RSB opinion

[1] COM(2019) 640 final, The European Green Deal

3. CONSULTATION OF THE RSB

First submission

The Regulatory Scrutiny Board (RSB) of the European Commission assessed a draft version of the present Impact Assessment on 7 July 2021 and issued its negative opinion on 9 July 2021.

The Board's main findings were the following and these were addressed in the revised impact assessment report as indicated below.

Main RSB findings	Revision of the Impact Assessment Report
(1) The report does not present a convincing case on the reasons for revising the Regulation at this point of time. It lacks clarity on the implications of related initiatives such as the CO_2 emission standards for new cars and vans proposal or the horizontal Ambient Air Quality Directives.	The impact assessment has been fully revised following the adoption of "fit-for-55 package" and hence the end-date of combustion-engine cars/vans by 2035 under the CO_2 emission standards for new cars and vans proposal was introduced in the modelling. The reasoning for the Euro 7 initiative, as announced in the European Green Deal, and the link to the Ambient Air Quality Directives has been clarified in chapters 1, 2, 5, 7 and 8.
(2) The performance of the option packages depends significantly on the final political choices on the proposal for CO_2 emission standards. The report does not deal adequately with this critical uncertainty	The implication of the end-date of combustion-engine cars/vans by 2035 has led to a revised baseline in chapter 5, a revised assessment in chapters 6 and 7 and discarded high ambitious policy option 3b on future sensor technology in section 5.3.
(3) The report does not present a clear comparison of option packages in terms of effectiveness, efficiency and coherence. The proportionality assessment of the preferred option(s) is not sufficiently balanced and informed by the most important costs and benefits. It does not sufficiently differentiate between light and heavy duty vehicles.	Chapter 7 has been fully revised to present a clear comparison of policy options in terms of effectiveness, efficiency and coherence and overall proportionality assessment, differentiated between light- and heavy-duty vehicles. For methodological reasons and for clarity purposes, the focus of the efficiency is on net benefits (i.e. present value of the benefits minus present value of the costs) which do not bias the results for low-cost options, in contrast to the benefit-cost ratio. New chapter 8 on preferred options has been elaborated, narrowing down the options for light- and heavy-duty vehicles based on the proportionality assessment in chapter 7 and informed by the most

	important costs and benefits.
(4) The report does not provide sufficient information on the robustness of the modelling work and the credibility of the quantitative estimates. It does not address the cumulative impacts from regulating road transport emissions on consumers, industry, competitiveness and employment. Differences in stakeholders' views have not been reflected sufficiently in the analysis.	The uncertainty and validation of the cost and benefits have been further elaborated in Annex 4, new section 1.3.2.1, discussed in chapter 6 and considered in the conclusions in chapters 7 and 8, to underpin the robustness of the modelling work and credibility of the quantitative estimates. Cumulative impacts from regulating CO_2 and pollutant emissions from road transport on consumers, competitiveness and employment have been assessed in chapter 6 and Annex 4, new section 1.5, and considered in chapters 7 and 8. Differences in stakeholders' views have been further reflected in chapters 6, 7 and 8.

The Board also mentioned the following improvements needed, which were addressed in the revised impact assessment report as indicated below.

RSB opinion: "what to improve"	**Revision of the Impact Assessment Report**
(1) The report should better explain the evolution of the problem of air pollutants related to road transport and the need for further action on reducing them. It should clarify upfront how a possible earlier end-date for introducing new combustion engine cars in the EU market would affect the magnitude of the problem and how big the problem of unaccounted real driving emissions is.	The magnitude and evolution of the problem of air pollutants related to air pollutants has been clarified in chapter 2. In particular, Figure 2 has been replaced to clarify upfront how an end-date of combustion engine cars and vans by 2035 affect the problem and how big the problem of unaccounted real driving emission is.
(2) For some emissions, the report should present the reduction efforts in their broader policy context. For example, the report should describe how this initiative interacts with the planned revision of Ambient Air Quality Directives. It should explain why industry specific action is necessary ahead of this horizontal revision and how it will ensure coherence and overall cost-efficient emission reduction.	The interaction with the planned revision of Ambient Air Quality Directives has been elaborated in chapters 1, 2, 5, 7 and 8, including an explanation how Euro 7 standards will contribute coherently and cost-efficiently to the horizontal revision, notably by supporting Member States in meeting their air quality commitments and ensuring a consistent coverage of all relevant air pollutants.

(3) The design of options packages should facilitate an understanding of the differences between certain types of actions. The actions on comprehensive real driving testing and extended durability are either both absent or both present in all options. The presentation of options should better distinguish between the effects of these measures.	The design of policy options has been revised in chapter 5 and subsequently in the analysis and conclusions, including a differentiation of real driving testing boundaries and durability and their effects in all options. Cost and benefit of each action included in the policy options are presented in Annex 3, if possible.
(4) The report should narrow the range of the preferred options, given the significant performance differences between the option packages, as well as between light and heavy duty vehicles. It should present clearly the trade-offs between the policy packages. In view of the low benefit-cost ratio of some option packages and the uncertainty as regards the robustness of the related estimates, the report should better justify the proportionality of the policy option packages.	Chapter 8 on preferred options has been elaborated, narrowing down the options to one preferred option 3a for light- and heavy-duty vehicles based on the comparison of the options in chapter 7, informed by the most important costs and benefits and presenting the main trade-offs that are left to policy-makers to decide. The proportionality of the preferred option for light-duty vehicles has been elaborated in chapter 7.4 in view of the low net benefits.
(5) The report should explain to what extent the analysis and the conclusions reached in the support studies are uncontested and verified. It should explain the buy-in of stakeholders to the conclusions, especially in relation to the technological potential for reducing emissions, the potential accelerated shift to electric vehicles and the impacts on competitiveness, where industry stakeholders seem to have different views. In case of remaining uncertainty, the report should complement the analysis by providing ranges of expected costs and benefits for the car and van option packages, based on alternative sets of assumptions on costs and benefits.	The uncertainty and validation of the cost and benefits have been further elaborated in Annex 4, new section 1.3.2.1. The medium to high level of confidence of the cost and benefit estimates verified by stakeholders and experts is considered sufficiently robust to present in chapter 6 average values for the cost and benefit elements. Nevertheless, the cost-benefit analysis in chapter 7 is complemented by providing ranges of expected costs and benefits to make political choices of the policy options for light- and heavy-duty vehicles. The buy-in of stakeholders to the conclusions is discussed in chapter 8, especially in relation to the technological potential for reducing emissions, the potential accelerated shift to electric vehicles and the impacts on competitiveness. In addition, an alternative set of assumptions on emission limits and durability to address remaining uncertainty in relation to technological potential for reducing emissions is

	assessed in Annex 8 and considered in chapters 7 and 8.
(6) The report should better discuss the cumulative impacts on consumers, employment and industry competitiveness. For example, when discussing affordability it should acknowledge that consumers will face not only the pass-on of additional regulatory costs from Euro7 but also from the new CO2 emission standards.	Cumulative impacts from regulating CO_2 and pollutant emissions from road transport on consumers, employment and competitiveness have been assessed in chapter 6 and Annex 4, section 1.5 and considered in chapter 7. For example, Annex 4, section 1.5.2 discusses the cumulative consumer affordability from Euro 7 and the new CO_2 emission standards for cars/vans.

Resubmission

The Regulatory Scrutiny Board (RSB) of the European Commission assessed the revised Impact Assessment and issued a positive opinion with reservations on 26 January 2022.

The Board's main findings were the following and these were addressed in the final impact assessment report as indicated below.

Main RSB findings	**Revision of the Impact Assessment Report**
(1) The report does not sufficiently reflect the significant differences in the scale of the problems, and corresponding need to act, between the cars/vans and lorries/buses segments.	The different contribution of light-duty compared to heavy-duty vehicles to the problem and need to act is better reflected in chapter 2. A box was added to highlight the differences between the two segments.
(2) The rationale behind the revised policy packages is not fully clear.	The rationale behind the revised policy packages is better explained in chapter 5.
(3) The report does not make a convincing case for the preferred option. The proportionality analysis does not bring out clearly enough the significant performance differences in terms of net benefits and benefit-to-cost ratios between the preferred options for cars/vans and lorries/buses respectively. The evidence presented on effectiveness, efficiency and coherence is not compelling enough to narrow the preferred options to one for both segments.	The reasoning for the preferred option 3a for light- and heavy-duty vehicles has been strengthened in chapter 8, including the underlying effectiveness, efficiency, coherence and proportionality analysis and evidence in chapter 7.

The Board also mentioned the following improvements needed, which were addressed in the final impact assessment report as indicated below.

RSB opinion: "what to improve"	**Revision of the Impact Assessment**

	Report
(1) The report should better reflect the significant differences in the scale and evolution of the problems between the cars/vans and lorries/buses segments in the analysis throughout the report. It should better justify the need to act as regards both segments in view of the planned phasing out of cars/vans with an internal combustion engine by 2035 and the limited time remaining to recoup the necessary investments. It should nuance the need to be the 'emission standard setter' and technological leader for a type of vehicle that will disappear from the market relatively soon.	The differences between light- and heavy-duty vehicles have been better reflected in the problem definition and throughout the report (chapters 2, 6, 7, 8). The report clarifies that the largest share of the costs for light- and heavy-duty vehicles occur in the first ten years after 2025 and only a small share of the costs remain after 2035, mainly resulting from the requirements regarding brake emissions for all cars/vans, including zero-emission vehicles. The need to be the emission standards setter and technological leader in the future was nuanced.
(2) While the report presents a revised and simplified set of policy packages, it should clarify whether these are the packages considered most relevant by stakeholders and whether other, possibly better performing, combinations of measures have been assessed. This should include, for example, an explanation why it has not considered continuous emission monitoring as part of the low ambition option package, to avoid rendering it a weaker option by design.	The rationale behind the revised policy packages is better explained in chapter 5, in particular why option 1 does not include new digital ambition and why the options presented are the best performing combination of measures while the actions have been differentiated in all options.
(3) The impact and proportionality analyses should bring out more clearly the significant performance differences between the preferred options for cars/vans and lorries/buses in terms of effectiveness and efficiency. Given that both – the net benefits and the benefit-cost ratios – are to a large extent higher for the lorries/buses segment, the report should argue more convincingly why equally ambitious action is justified as regards cars and vans. This assessment should take into account that the low green ambition option offers net benefits that clearly outperform the high green ambition options (2b) and comes relatively close to those available under the medium green ambition option (2a) while offering by far the best benefit-cost ratio among the considered cars/vans options. The narrowing of preferred options should	The effectiveness, efficiency, coherence and proportionality analyses have been strengthened in chapter 7 acknowledging the higher net benefit of heavy-duty vehicles, while underlining that also the lower net benefit of light-duty vehicles would make transport drastically less polluting, especially in cities. Chapter 7 discusses better why for methodological reasons and for clarity purposes, the focus of the efficiency is on net benefits (i.e. present value of the benefits minus present value of the costs) which do not bias the results for low-cost options, in contrast to the benefit-cost ratio. The reasoning for the preferred option 3a for light- and heavy-duty vehicles has been strengthened in chapter 8, including

take into account all available evidence presented in the report, including, to the extent possible, the acceptance of the stakeholders and the potential concerns of social acceptability of continuous emissions monitoring as the report states.	the acceptance of stakeholders (industry, NGOs, citizens).
(4) The report (still) needs to be clearer on how big the problem of unaccounted real driving emissions is. It should assess the robustness of the evidence that 20% of current real-driving testing may exceed significantly the current emission limits. The results of the preliminary analysis done for the revision of the EU air quality legislation should be better presented, including in a more accessible manner.	Evidence on the 20% unaccounted real driving emissions and results of the preliminary analysis done for the revision of the EU air quality legislation have been added in chapter 2.

4. EVIDENCE, SOURCES, QUALITY AND EXTERNAL EXPERTISE

In autumn 2018, preparatory work of the Euro 7 initiative started with the first stakeholder conference organised in October. During this conference, an Advisory Group on Vehicle Emission Standards (AGVES) was set up by joining all relevant expert groups working on emission legislation (see Annex 2 for more details on AGVES). The broad evidence and sources provided and discussed in this expert group are available in the public AGVES CIRCABC[2].

In further preparation of the initiative and to collect convincing and robust scientific evidence, a first post-Euro 6/VI study (Part A) was launched with the tasks to review, compare and draw lessons from legislation in other part of the world, evaluate the effectiveness of current EU emission tests and develop and assess new emission tests for regulated and non-regulated pollutants[3]. As a follow-up for this first study, a second commissioned study, post-Euro 6/VI Study Part B, covered a thorough review of the cost-effectiveness of measures that were introduced by the first study in addition to a feasibility assessment of new pollutant emission limits for all vehicles and an analysis of the simplification potential of vehicle emission standards. This study also supported the evaluation of the Euro 6/VI framework, while providing the evidence necessary for this impact assessment.[4] Both studies were carried out by the CLOVE consortium which

[2] AGVES CIRCABC, This group has been established to facilitate the exchange of information between the members of the Advisory Group on Vehicle Emission Standards (AGVES).

[3] CLOVE, 2022. Study on post-Euro 6/VI emission standards in Europe – Combined report: PART A including PART B Techno-economic feasibility of new pollutant emission limits for motor vehicles. The findings from the study were presented and discussed continuously in the AGVES meeting.

[4] CLOVE, 2022. Study on post-Euro 6/VI emission standards in Europe – PART B Potentials for simplification of vehicle emission standards; CLOVE, 2022. Study on post-Euro 6/VI emission standards in Europe – PART B: Retrospective assessment of Euro 6/VI vehicle emission standards; CLOVE, 2022. Study on post-Euro 6/VI emission standards in Europe - PART B: Assessment and comparison of post-Euro 6/VI impact assessment options. The findings from the studies were presented and discussed continuously in each AGVES meeting.

included key experts in Europe from the Laboratory of Applied Thermodynamics of the Aristotle University of Thessaloniki (LAT) (GR), Ricardo (UK), EMISIA (GR), TNO (NL), TU Graz (AT), FEV (DE) and VTT (FI). Both studies were underpinned by analysis and tests performed by the Joint Research Centre of the Commission, in its facilities located in Ispra Italy. Further elements were considered taking advantage of work performed in the context of UN GRPE[5] (Working Party on Pollution and Energy) for the harmonisation of emission type approval regulations. Such elements included battery durability and brake emissions.

Since the post-Euro 6/VI Study Part B supported both the evaluation and the impact assessment, it also helped collecting evidence and data through different channels, including both targeted stakeholder consultations on the evaluation and impact assessment (see Annex 2). When it comes to estimating the costs for both the impact assessment and the evaluation, the contractors had some difficulties due to limited provision of cost data by stakeholders during the targeted consultations. To prevent implications on the robustness of the findings, the methodology was changed to consider additional data from various databases, including EEA NECD database[6], Euro 6/VI vehicle sales data from IHS Markit[7], OECD statistics[8], the Handbook on external costs and emission factors of Road Transport[9], structural business statistics from Eurostat[10], data requests to type-approval authorities and CLOVE expertise. The subsequent estimates have later been validated by key stakeholders to ensure robust results.[11]

[5] https://unece.org/transportvehicle-regulations/working-party-pollution-and-energy-introduction
[6] EEA, 2021. National Emission reduction Commitments Directive (NECD) emissions data viewer 1990-2018
[7] IHS Market, 2021. Provision of data on vehicle sales in the EU-28 for Evaluation of Euro 6/VI vehicle emission standards
[8] OECD, 2020. Statistics on Patents –Technology Development Environment
[9] European Commission, 2019. Handbook on the external costs of transport
[10] Eurostat, 2020. Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E) [sbs_na_ind_r2]; Eurostat, 2020. Passenger cars, by age [road_eqs_carage]; Eurostat, 2020. Passenger cars, by type of motor energy [ROAD_EQS_CARPDA]
[11] For more information see CLOVE, 2022. Euro 6/VI Evaluation Study. ISBN 978-92-76-56398-3, chapter 4.2. Study limitations.

Annex 2: Stakeholder consultation

1. Introduction and overview consultation activities

This synopsis report summarises all the consultation activities for the preparation of the proposal for the development of Euro 7 emission standards for cars, vans, lorries and buses. The consultation process for this development was more extensive than what is usually reserved for similar regulations and went into details of the testing regime, boundary conditions and technologies required to achieve the emission limits.

The initiative was discussed for the first time with stakeholders during a stakeholder conference in October 2018[12]. Subsequently, the Advisory Group on Vehicle Emission Standards (AGVES) was set up by merging relevant expert groups from industry, civil society and Member States, with ten meetings and one ad-hoc workshop on simplification from July 2019 to April 2021. The result of these extensive consultation activities were used for the preparation of the Euro 6/VI evaluation and Euro 7 impact assessment.

The Inception Impact Assessment (IIA) was launched on the "Have your say" page of the Europa website on 27 March to 3 June 2020. The 18-week Public Consultation (PC) on the proposal followed on 6 July 2020 and was open for contributions until 9 November 2020. In addition, two 14-week targeted consultations (TC) – one for the Evaluation of Euro 6/VI (4 March to 8 June 2020) and one for the Impact Assessment of Euro 7 (3 August to 9 November 2020) – were performed by the CLOVE consortium focussing more on the detailed and technical aspects of to the initiative. Due to the effects of COVID-19 and containment measures, the public and targeted stakeholder consultations were extended by 6 weeks.

The stakeholder consultation was intended to collect evidence and views from a broad range of stakeholders and citizens with an interest in vehicle emissions. The aim was assessing the five evaluation criteria of the Euro 6/VI[13] (see Annex 5) as well as potential impacts of the reviewed framework. Since this Impact Assessment took a back-to-back approach, both questions on the implementation of the current Euro 6/VI emission standards and potential policy options regarding the Euro 7 initiative were considered for the different consultation activities. For this purpose, the views of each stakeholder group were considered important (see 2.1).

The main communication channel was the "Have your say" portal for the PC and the public AGVES CIRCABC and extensive bilateral communication with stakeholders for the TC. Awareness of the PC was also raised on Commission websites, platforms such as EIONET, social networks and newsletters. The link to the PC was also shared with appropriate representatives from Member State authorities, who were encouraged to reach out to national stakeholders, as well as with the European Economic and Social Committee and the European Parliament. In addition, the stakeholders participating in

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[12] Preparing automotive emission standards for the future | Internal Market, Industry, Entrepreneurship and SMEs (europa.eu)

[13] Regulation (EC) No 715/2007 on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and its implementing Regulation (EU) 2017/1151; Regulation (EC) No 595/2009 on type-approval of motor vehicles and engines with respect to emissions from heavy-duty vehicles (Euro VI) and its implementing Regulation (EU) No 582/2011

the AGVES meetings were especially encouraged to contribute.

2. RESULTS OF THE CONSULTATION

2.1. Description of the respondents

Table 1 provides an overview of the number of stakeholders that participated in each consultation activity described above. The PC also includes the feedback received on the IIA. Stakeholders are divided in three large groups, namely Member States and national authorities (hereafter referred to as "Member States"), automotive industry and civil society. The group, civil society, is a combination of separated groups from the consultation strategy: consumer organisations, environmental NGOs and other stakeholders. Since contributions from these separate groups were limited in certain activities, the aggregate was considered for the analysis. In case of striking differences, the categories are discussed in parallel. Citizens participated only in the consultation activities open to the public.

Each stakeholder group has a different level of interest and is either directly or indirectly affected by the current and future vehicle emissions standards. In the TC, a number of interviews with stakeholders were also conducted by the CLOVE consortium, further elaborating on the responses to the questionnaire. Comments received during these interviews were integrated in the analysis.

Table 1 – Participation rates per stakeholder group, category and activity

Stakeholder group	Category	Consultation activity			
		Public consultation	Targeted consultation evaluation	Targeted consultation impact assessment	Expert groups of the Commission
1.Member States and National Authorities	National, regional and local authorities	20	9	7	3
	Type-approval authorities	1	5	2	—
	Technical services	1	7	7	—
2.Automotive Industry	Vehicle manufacturers	20	14	16	4
	Component suppliers	46	12	17	6
	Associations/Other industry stakeholders	54*	17	12	9
3.Civil Society	Consumer organisations	7	2	2	2
	Environmental NGOs	12	3	2	2
	Other stakeholders	8	4	2	—
4.Citizens[14]	—	64	—	—	—
Total	—	233	73	67	24

* including 30 contributions from fuel and energy industry

2.2. Analysis of responses

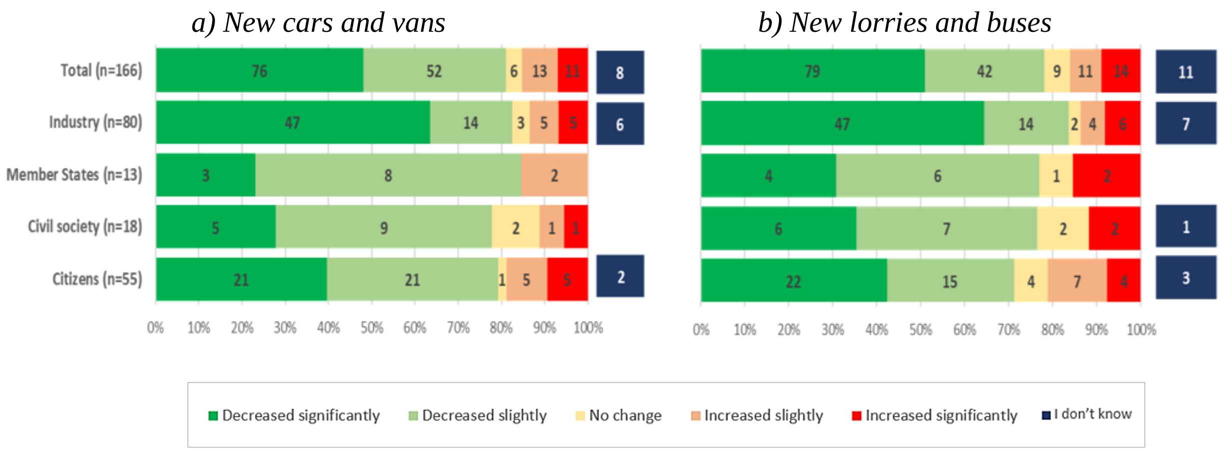
2.2.1. Evaluation Euro 6/VI emission standards

As presented in Figure 1, in the PC stakeholders from all groups believe that over the last

[14] The lower response rate is not necessarily a problem, since the interest of the general public is represented by both the respondents from civil society and from Member States and national authorities.

10 years, air pollution from new vehicles has reduced suggesting a positive perception of Euro 6/VI's effectiveness.

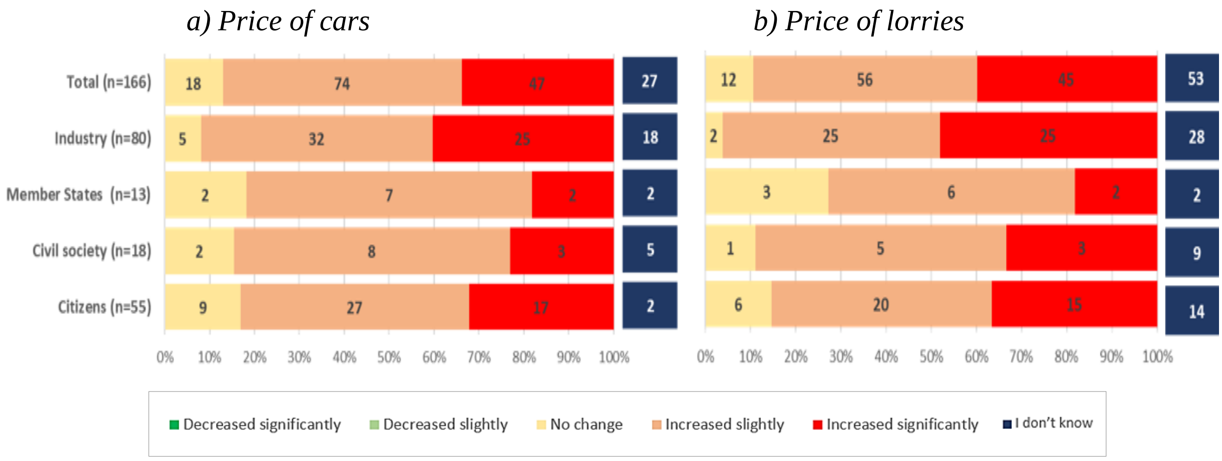
Figure 1 – PC Q3: Over the past 10 years, based on your experience what has happened to air pollution originating from:



The responses from all groups participating in the TC suggest that the Euro 6/VI has made vehicles on EU roads cleaner with the majority of automotive industry considering Euro 6/VI as the most important factor. In TC and PC, two suppliers and an environmental NGO also indicated that there is room for improvement to meet the targets of the European Green Deal. While the responses from all stakeholder groups to TC suggest that the introduction of RDE testing reduced the gap between type-approval and real-world emissions, in PC the majority of industry and citizens indicated that RDE testing truly ensures that cars and vans are compliant with the pollutant limits in all driving conditions. In addition, responses from all groups to PC, excluding industry, suggest that the current shortcomings in the existing on-road tests at least contribute somewhat to increasing emissions. In different activities, automotive industry stressed that the actual impact of the latest standards is not yet fully known and that air quality modelling is important to determine what measures will lead to improved air quality.

While in TC the regulatory costs associated with the standards were reported to have increased significantly with Euro 6/VI by the groups (civil society to a lesser extent), the majority of automotive industry and Member States indicated that compared to the benefits for their organisation the costs were not high. Additionally, the responses from all stakeholder groups suggest that the costs compared to the benefits for society are low. Next to that, Figure 2 illustrates that the vast majority of all groups in PC were of the view that Euro 6/VI has increased vehicle prices. Further, the majority of stakeholders from all groups in TC and PC indicated that instead of achieving simplification, Euro 6/VI has resulted in further complexities in nearly all aspects (e.g. tests, differences in limits, reporting requirements). Lastly, a key consumer organisation in TC indicated that the last Euro 6d step including the introduction of RDE testing had positive effects on consumer trust damaged by Dieselgate.

Figure 2 – PC Q3.1: In your view, what effect did the Euro 6/VI standards have on the price of the following vehicles?[15]



The responses from automotive industry, Member States and civil society to TC highlight that there are ongoing air pollution and health issues associated with road transport and that there is still need for action. In addition, key environmental NGOs stressed that there is no safe level of air pollution. When asked to evaluate policy measures based on their success in limiting vehicle emissions in the PC, the majority of all groups indicated that strict regulations are the most successful. Still, the majority of civil society and Member States indicated that the current emission limits are not strict enough, while the majority of all groups believes that Euro 6/VI does not cover all relevant pollutants. In addition, the results of PC suggest that the majority from all groups apart from industry believes that vehicles do not comply with emission limits in all driving conditions and over their entire lifetime. The responses to TC suggest that, despite the emergence of electric vehicles, the cleaning of the ICE remains relevant for all groups.

The responses from all groups to TC suggest that overall manufacturers are provided with a coherent legal framework. However, a large share from industry indicated that there are important internal inconsistencies in relation to the emission limits, requirements and testing procedures, especially for cars/vans. Additionally, a significant part of the respondents from industry and the Member States reported incoherence of Euro 6/VI emission standards with Ambient Air Quality directive[16] and the CO_2 emissions[17]. A majority of respondents from Member States and civil society indicated incoherencies with the Roadworthiness Directives[18].

The results of TC and PC illustrate that the majority of from all groups believe that there is significant added value in regulating vehicle emissions at EU level compared to what could have been achieved at national or international level. Still, industry believes that lower costs could be achieved when emissions were regulated at international level.

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[15] Similar results were found for the price of vans and buses.

[16] Directive 2008/50/EC on ambient air quality and cleaner air for Europe

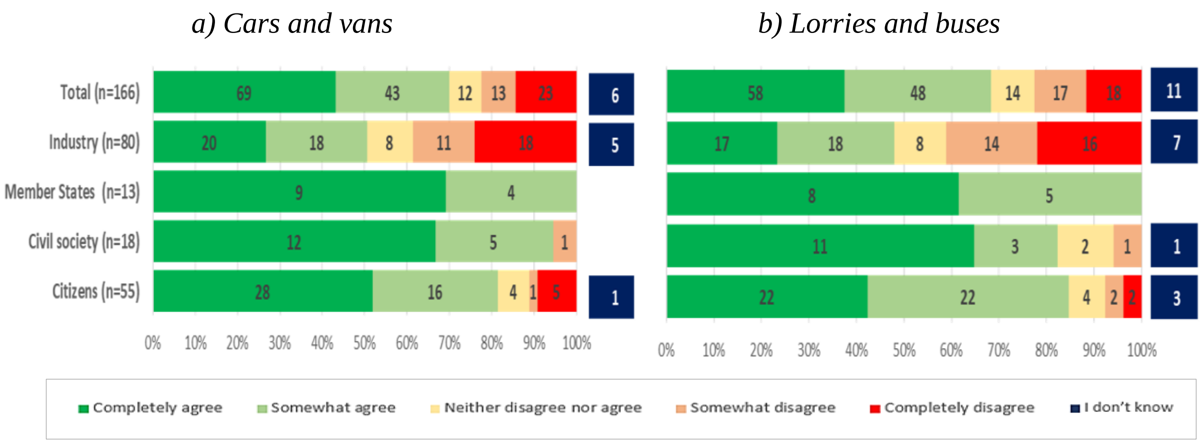
[17] Regulation (EU) 2019/631 setting CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) No 443/2009 and (EU) No 510/2011; Regulation (EU) 2019/1242 setting CO_2 emission performance standards for new heavy-duty vehicles

[18] Directive 2014/45/EU on periodic roadworthiness tests for motor vehicles and their trailers; Directive 2014/47/EU on the technical roadside inspection of the roadworthiness of commercial vehicles circulating in the Union

2.2.2. *Baseline*

The results from PC emphasise that the majority of Member States, civil society and citizens consider new Euro standards to be appropriate to further reduce vehicle emission. For automotive industry 29 respondents disagree for cars/vans, while 30 disagree for lorries/buses (Figure 3).

Figure 3 – PC Q5: To what extent do you agree with the following statements? New Euro standards would be appropriate to further reduce air pollutant emissions from:

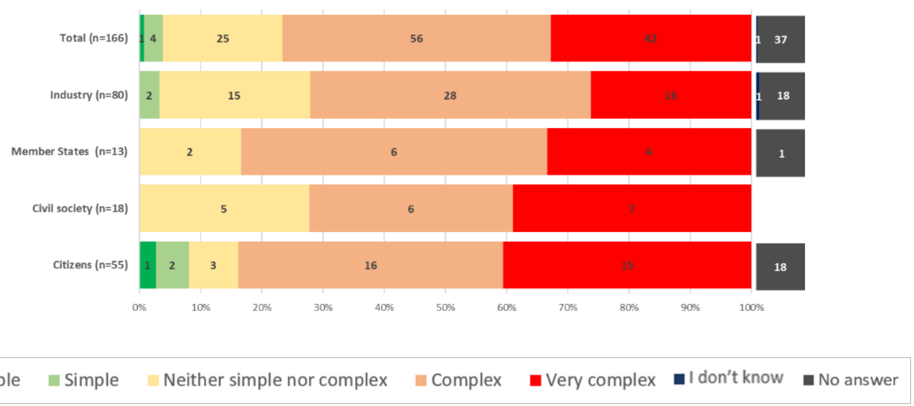


Also in other activities, industry stressed that preserving the Euro 6/VI is a realistic and balanced option. They claim that without action industry is given better stability, while further improvements in air quality would be realised through the renewal of the fleet and through focussing on CO_2 measures. Several stakeholders from civil society and industry indicated in PC that a new Euro emission standard is needed.

2.2.3. *Simplification measures*

The results from PC showed that the majority from all groups consider Euro 6/VI to be complex (Figure 4). While a large share of industry stakeholders reported inconsistencies for Euro 6/VI in TC, the responses from civil society and Member States suggest that the legislation for lorries/buses is considered less complex. The responses to PC from all groups show that complexities lead to significant compliance costs and administrative burden. Additionally, all groups apart from industry believe that complexity hampers environmental protection, while civil society adds that it leads to misinterpretations.

Figure 4 – PC Q8: Please indicate if you consider the Euro 6/VI simple or complex.



Single legislative tool

The responses to PC suggest that the majority from all groups, especially industry, does not support introducing a single Euro emission standard for cars, vans, lorries and buses due to lack of understanding what this would imply. Industry indicated that the two standards should remain distinct to allow for proper differentiation and international harmonisation. Still, Member States express support to merge the basic acts for Euro 6/VI with almost identical legal structure (715/2007 and 595/2008). Support from all groups is given towards eliminating the currently overlapping area between the two regulations.

Streamlined testing and uniform limits

The results of PC demonstrate that a large majority across all groups considers the introduction of technology-neutral limits and testing to be important to reduce complexity. Member States, civil society and citizens also support the introduction of common application dates for new vehicle types and new vehicles, automotive industry does not consider this to be feasible. Automotive industry showed great support for the removal of obsolete tests in all consultation activities. Member States were rather divided on the matter. In TC, industry was sceptical regarding the replacement of all laboratory-based tests by extended on-road testing, which was generally supported by the other groups. In PC the vast majority of Member States, civil society and citizens believe that shortcoming in the existing on-road tests contribute to an increase in emissions. Stakeholders from all groups already mentioned in their feedback to IIA that RDE and PEMS need to be improved to cover all or more conditions of use. Additionally, Member States and civil society (and industry to a lesser extent), consider it important to extend the operation conditions (e.g. trip duration) and environmental conditions (e.g. temperatures). Through AGVES, industry indicated that such extensions should take into account the statistical relevance of these conditions.

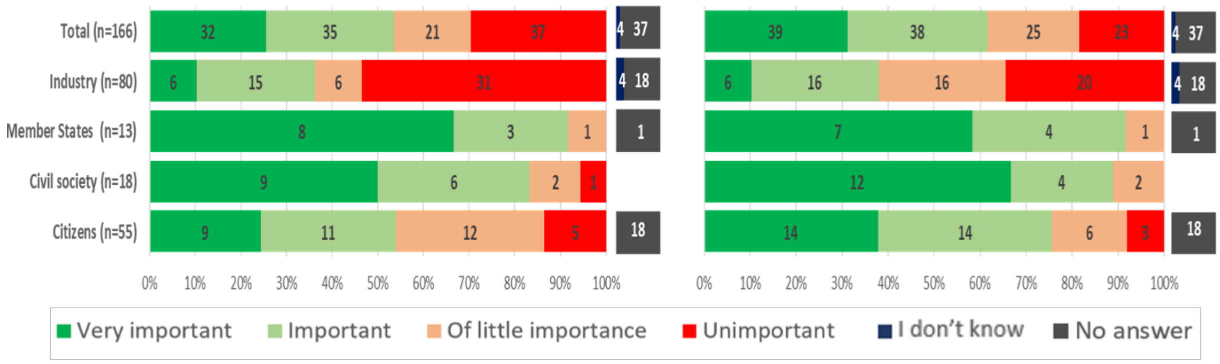
2.2.4. Stricter air pollutant limits for new vehicles

Figure 5 shows that apart from industry, the majority of all groups in PC show support for the development of stricter limits for regulated pollutants and new limits for non-regulated pollutants.

Figure 5 – PC Q13: Indicate to what extent the following actions are important to improve the effects of emission limits.

a) Developing stricter limits for regulated pollutants

b) Setting new limits/testing procedures for non-regulated pollutants



Stricter limits for regulated pollutants

The responses to PC indicate that the vast majority from Member States, civil society and citizens believe that the current emission control technology leave room for additional reductions. Through AGVES and IIA, three environmental NGOs, one main supplier and a respondent from the fuel- and energy industry expressed that technologies to further reduce the emissions are mature and either already or close to be commercially available. Other industry stakeholders mentioned in the different activities that reviewing the limits should start with a careful assessment of the real benefits for air quality. The result from the public consultation shows that most stakeholders from civil society and Member States consider the current limits for NO_x and PM/PN to be insufficiently strict.

New limits for non-regulated pollutants

The large majority of stakeholder from Member States, civil society and citizens in PC indicated that there are emerging unregulated air pollutants. In both PC and TC, several stakeholders (mostly industry), declared that such pollutants should only be regulated if they can be reliably measured and if regulating them would have real benefits for air quality. When looking into which pollutants should be added, both consultation activities suggest high support from Member States and civil society in reducing the size of PN emissions to also cover ultra-fine particles. High support was also given towards the inclusion of non-exhaust emissions (i.e. brake and tyre emissions). The majority of respondents from Member States, civil society and citizens mentioned the increasing importance of these emission sources following the rising popularity of larger and fast-accelerating vehicles (e.g. SUVs, battery electric vehicles). Also, introducing an NH_3 limit for cars and vans receives significant support from Member States and civil society. Including limits for NO_2, N_2O and CH_4 (for cars and vans) is also supported by these groups, but to a lesser extent. In TC, however, the majority of industry and Member States indicated that separate NO_2 limits are not necessary, as long as NO_x emissions remain low in real-world conditions.

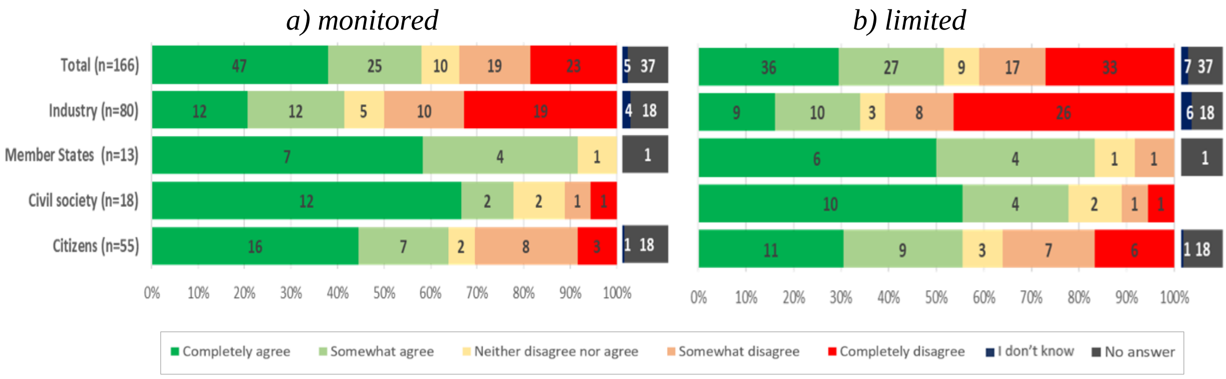
Through their feedback to IIA, several industry stakeholders underlined that legislative changes should be preceded by a careful cost-benefit analysis, which considers the current economic situation, and incentives for the introduction of more advanced technology by early adopters are important.

Real-world emissions and durability

Figure 6 illustrates that in PC the majority of all groups, excluding automotive industry, believe that in Euro 6/VI real-world emissions are not adequately monitored or limited over the entire lifetime of vehicles. Tampering, vehicle ageing, inadequate technical inspections and the cost of maintenance were indicated as potential causes. In all activities all groups have shown support for the development of clear requirements for the protection against tampering.

Through feedback to IIA, a number of stakeholders from industry, Member States and environmental NGOs indicated that emission performance should remain consistent over the real lifetime of vehicles and that durability requirements need to be extended to ensure this. In TC, the majority from Member States, civil society and industry (to a lesser extent) identified the importance of limiting emissions over the average age of vehicles until the end-of-life. In the AGVES meetings, stakeholders from civil society have stressed on several occasions that while on average cars in the EU are 10.8 years, cars stay on the road much longer in Eastern and Southern Europe, often in excess of 15 years. Most manufacturers stressed in this consultation that the emissions of older vehicles are generally dependent on maintenance which is outside their responsibility.

Figure 6 – PC Q14: To what extent do you agree with the following statements? Real-world emissions are not adequately *[insert a/b]* over the entire lifetime of a vehicle in Euro 6/VI.



2.2.5. *Continuous emission monitoring*

While only few manufacturers expressed support, the results of PC show that the majority of the other stakeholder groups support the implementation of continuous emission monitoring (CEM) of emissions as an action to measure real-world emissions. In TC, a large majority from automotive industry and all respondents of Member States and civil society indicated a combination of methods, such as new on-board monitoring (OBM) and existing on-board diagnostics (OBD), may be required to ensure lifetime compliance. The large majority of manufacturers, however, indicated that they do not know whether such a combination of methods would be required. In addition, most manufacturers added that OBM can only be used for a limited number of pollutants in the near future. Regarding how OBM should be used, the majority of respondents from industry, Member States and civil society in TC somewhat agreed that the relevant values should be read-out during technical inspections. On the other hand, two suppliers and one Member State consider “over the air transfers” to be more effective. In their feedback to IIA, two industry respondents indicated that that CEM in combination with stricter limits could be overly burdensome for European manufacturers.

In PC, geo-fencing was only considered to be an important action for improving the effect of emission limits by a majority of respondents from the Member States and citizens. The responses to TC suggest that civil society thinks that a vehicle should be operated in zero-emission mode in more polluted areas. The responses from automotive industry to this consultation, on the other hand, suggest that they think it would be difficult to precisely monitor and enforce geo-fencing.

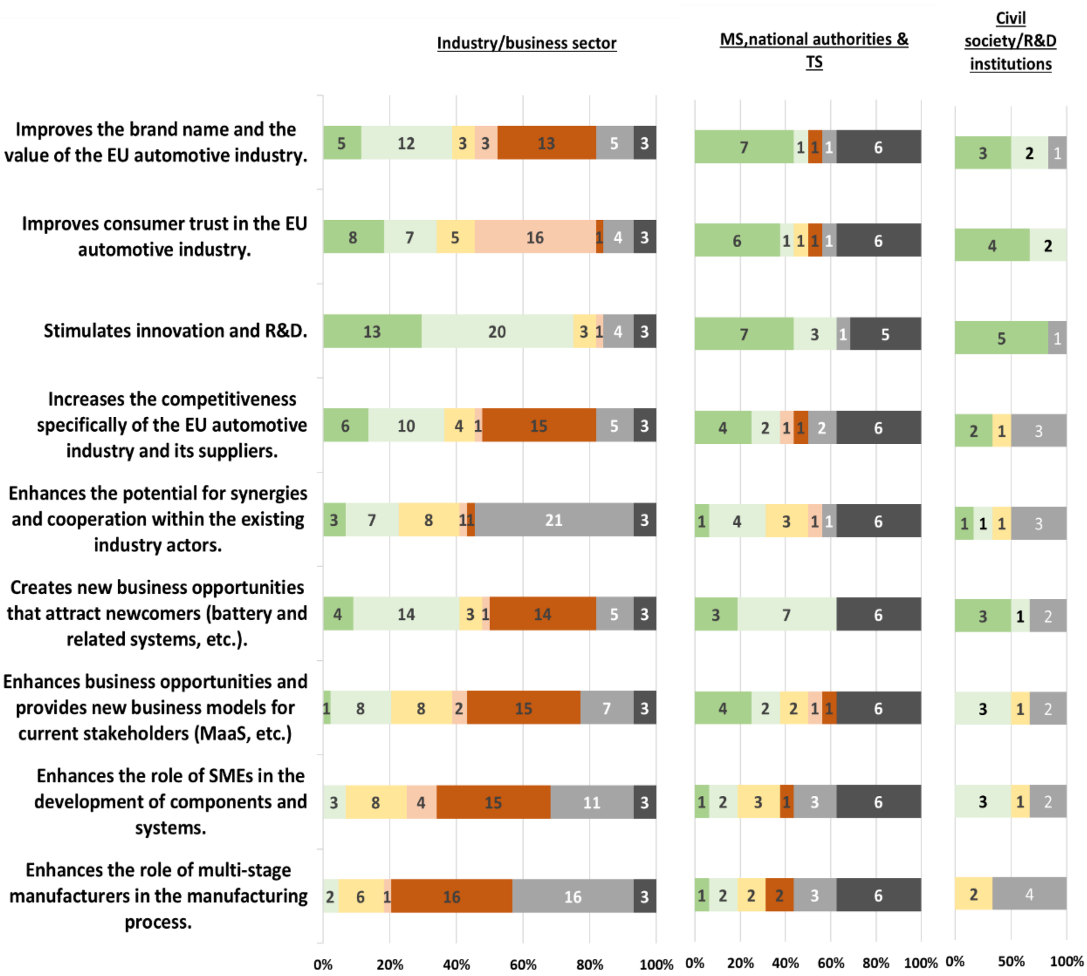
2.2.6. *Impacts of a stricter emission standard*

Through TC, views on the possible impacts of new emission standards on industry competitiveness were collected. The results in Figure 7 show that while Member States and civil society generally expect a positive relationship between stricter standards and competitiveness, differing views were found amongst industry stakeholders with suppliers anticipating positive impacts and manufacturers anticipating negative impacts.

Almost half of the suppliers stressed that new limits will create new business opportunities and quality jobs. A large share of industry, Member States and civil society stakeholders indicated that a higher-level education and new skills will be required for the majority of the personnel. The majority of vehicle manufacturers, however, expressed concern that stringent emission limits and testing over all driving conditions may accelerate the shift to electric vehicles or even take the ICE off the market. About half of industry claimed that employment in businesses focused on traditional ICE and/or exhaust after treatment parts would be negatively affected.

Input from TC on consumer affordability indicated that the majority from industry consider stringent emission limits to increase the price of vehicles and to reduce demand and fleet turn-over. In PC, the majority from Member States and civil society disagreed that the Euro standards are too costly and make cars unduly expensive. In, TC a consumer organisation stated that the previous Euro standards illustrate that an appropriate level of ambition can make vehicles significantly cleaner while not making them disproportionately more expensive.

Figure 7 – TC Q14: Please indicate to what extent you agree or disagree with the following statement(s) relating to how stricter post-Euro 6/VI standards may affect the relevant EU industry[19]



[19] Supporting Euro 7 impact assessment study, Annex II: Input from targeted stakeholder consultation (10.6 Other impacts of new vehicle emission standards)

2.3. Use of Consultation Results

The replies to the three questionnaires as well as information and data through all consultation activities were taken into consideration for the evaluation of the Euro 6/VI and for the preparation of the Euro 7 impact assessment. The collected stakeholder evidence made it possible to supplement, cross-check and confirm the evidence already gathered through other research (see Annex 4) in this staff working document and the supporting studies[20,21,22,23,24].

Depending on the nature of the specific questions, the responses were analysed in the Euro 6/VI evaluation and Euro 7 impact assessment quantitatively or qualitatively for each stakeholder group. For this purpose, the closed questions (Yes/No and Likert-scale questions) in PC[25] and TC[26] were analysed using visual aids, such as bar charts, while the responses to the open questions and other feedback were examined by labelling and organising common elements in the responses over the different stakeholder groups. If no clear position was expressed within the same group, the groups were further disaggregated based on the sub-groups to identify common views. In the case of the Member State and civil society stakeholder groups, the views were generally found to be consistent. The further disaggregation was especially relevant in the case of automotive industry, where vehicle manufacturers and component suppliers often had differing views. In addition to this, the individual manufacturers and suppliers coordinated their responses to the different consultation activities through the main manufacturers and suppliers associations (ACEA and CLEPA).

The feedback from all stakeholder groups has been taken into account for evaluating Euro 6/VI. Feedback and differences in stakeholders' views were carefully analysed and taken into account if credible. Stakeholder views from industry and Member States have been particularly useful for identifying the standards' effectiveness, efficiency and coherence. For evaluating relevance and EU-added value, views from all stakeholder groups have been taken into account. All feedback and concerns were taken into account in the Euro 7 impact assessment. In particular, the views from industry and Member States were helpful to analyse the problem of complexity and in that way develop option 1 and information provided by industry on the hardware costs for emission control technologies were assessed in option 2 and 3. Feedback and concerns raised by the Member States, industry, civil society and citizens have been taken into account in the design and assessment of the options, particularly with regard to the technological potential for reducing emissions by emission limits, durability, testing conditions and CEM, the potential accelerated shift to electric vehicles and the impacts on competitiveness, where industry stakeholders seem to have different views.

[20] CLOVE, 2022. Technical studies for the development of Euro 7. Testing, Pollutants and Emission Limits. ISBN 978-92-76-56406-5.
[21] CLOVE, 2022. Technical studies for the development of Euro 7: Simplification. ISBN 978-92-76-56405-8.
[22] CLOVE, 2022. Technical studies for the development of Euro 7: Durability of light-duty vehicle emissions. ISBN 978-92-76-56405-8.
[23] CLOVE, 2022. Euro 6/VI Evaluation Study. ISBN 978-92-76-56398-3.
[24] CLOVE, 2022. Euro 7 Impact Assessment Study. ISBN 978-92-76-58693-7
[25] European Commission, 2020. Presentation AGVES Meeting 26 November 2002: Post-Euro 6/VI public stakeholders consultation (Question 5)
[26] See footnote 20 and 21

The widely supported view against the introduction of a single Euro emission standard for cars/vans and lorries/buses was not entirely considered, since the objectives of proper differentiation as well as international harmonisation stated by industry should be achievable also with the basic acts (715/2007 and 595/2008) merged while the specific implementing regulations are kept separate. This was confirmed with the stakeholders in the follow-up interviews linked to the targeted consultation on the impact assessment and in the AGVES meeting of 16 November 2020.

Annex 3: Who is affected and how?

1. Practical implications of the initiative

The Euro 7 emission standards will apply to vehicle and component manufacturers active in the automotive supply chain and national authorities responsible for type-approval of vehicles in the Member States. They will need to comply with the requirements of the Euro 7 emission standards summarised in Table 2.

Table 2 - Summary of Euro 7 requirements

What	By whom	By when
Option 1		
Adapt vehicle production to technology-neutral limits for certain regulated pollutants.	Manufacturers, including component suppliers.	2025
Apply or witnessing simplified and revised testing procedures for emission testing of cars, vans, lorries and buses.	Manufacturers, including component suppliers. National authorities responsible for type-approval.	2025
Granting Euro 7 emission type-approvals	National authorities responsible for type-approval.	2025
Checking compliance during market surveillance	National authorities responsible for market surveillance	2025
Option 2		
Adapt vehicle production to medium/high ambitious emission limits, testing procedures and durability.	Manufacturers, including component suppliers	2025
Apply or witnessing simplified and revised testing procedures for emission testing of cars and vans, and lorries and buses.	National authorities responsible for type-approval. Manufacturers, including component suppliers.	2025
Granting Euro 7 emission type-approvals	National authorities responsible for type-approval.	2025
Checking compliance during market surveillance	National authorities responsible for market surveillance	2025
Option 3		
Adapt vehicle production to medium ambitious emission limits, testing procedures and durability.	Manufacturers, including component suppliers	2025
Adapt vehicle production to continuous emission monitoring (CEM).	Manufacturers, including component suppliers.	2025
Shift part of the emission testing to controlling emissions through CEM functions.	National authorities responsible for type-approval.	2025
Granting Euro 7 emission type-approvals	National authorities responsible for type-approval.	2025
Checking compliance during market surveillance	National authorities responsible for market surveillance	2025

2. SUMMARY OF COSTS AND BENEFITS

2.1 Euro 6/VI evaluation

Table 3 - Overview of costs and benefits following the introduction of the Euro 6/VI emission standards[27]

I. Overview of costs – benefits identified in the evaluation for EU-28				
Type of costs and benefits[28]	**Stakeholder group**			**Overview of costs and benefits identified in the evaluation[29]**
	Manufacturers and suppliers	**Administrations**	**Citizens and consumers**	
Direct costs (regulatory costs)				
1) Equipment costs Compared to the estimates of the former Euro 6/VI Impact Assessments: €213 per diesel LDV[30] €2 539-€4 009 per HDV	**X**			• **Hardware costs** Cost of €228-€465 per petrol LDV and €751-€1703 per diesel LDV (moving from Euro 5 to Euro 6d) Cost of €1 798-€4 200 per HDV Total cost up until 2020: €17.2–€43.2 billion for Euro 6 €4.1-€9.5 billion for Euro VI High level of confidence that costs are within the above intervals. Costs per vehicle are expected to decline gradually following a learning effect. • **R&D, calibration, facilities, tooling costs** €36-€108 per petrol LDV and €43-€156 per diesel LDV €1 900-€3 800 per HDV Total cost up until 2020: €3.1-€10.7 billion for Euro 6 €5.35-€10.7 billion for Euro VI Also for suppliers in the form of costs for the development of new equipment, but partly covered by hardware costs for manufacturers. Moderate level of confidence due to limited data points and variation between manufacturers (wide range intended to capture this).
2) Costs during implementation phase	**X**	**X**		• **Testing and witnessing costs for manufacturers and suppliers** Cost of €150-€302 thousand per model family for LDV (moving from Euro 5 to Euro 6 d) Cost of €95.7-€232 thousand per engine family for HDV Total cost up until 2020: €401-€921 million for Euro 6 €52.5-€128.8 million for Euro VI

[27] All estimates for the cost and benefits are based on the Supporting evaluation study (CLOVE, 2022), which are featured in Annex 5: Evaluation Euro 6/VI emission standards

[28] Detailed explanations of the cost typology for manufacturers and supplier can be found in Table 39 in Annex 5: Evaluation Euro 6/VI emission standards

[29] More detailed cost estimates for the regulatory costs for manufacturers can be found in Table 40 in Annex 5: Evaluation Euro 6/VI emission standards

[30] In the Euro 6 Impact Assessment, no estimates were made for petrol cars and vans. It only focused on the cost of the key technology expected to be needed to comply with the limits (SCR or LNT) and did hence not cover other aspects such as the costs of sensors and other supporting hardware. In addition, only the initial stages of Euro 6 (prior to changes in the testing requirements, including RDE testing).

				Medium level of confidence as a result of the limited data provided and the different way that manufacturers go about type-approval (grouping of model/engine families) (broad range reflects this uncertainty). • **Witnessing costs for type-approval authorities** Euro 6 resulted in a medium increase in costs mainly from training and more demanding testing and witnessing requirements. Expected to be largely covered by manufacturers. • **Type-approval fees for manufacturers** Total cost up until 2020: €6-€10 million for Euro 6 The overall fee per type-approval remained small (€0-€1 500). Increase in total costs for cars and vans realized through an increase in the number of emission type-approvals. Medium to high level of confidence based on data on fees charged by 6 authorities and confirmed by manufacturers.
3) Administrative costs	**X**			Cost of €16-€52 thousand per LDV type approval (moving from Euro 5 to Euro 6d) Cost of €17.5-€27.5 thousand per HDV type approval Total cost up until 2020: €247-€794 million for Euro 6 €26-€41 million for Euro VI Medium level of confidence (see explanation witnessing costs)
Total regulatory costs 1)+2)+3)	**X**	**X**		• **Total costs for manufacturers and suppliers** Based on the sector market structure, all regulatory costs to industry are expected to be passed down to consumers. Total cost up until 2020: €21.1-€55.6 billion for Euro 6 €9.5-€20.4 billion € for Euro VI • **Total costs for type-approval authorities** Total cost associated with the implementation process (see above). Expected to be largely covered by manufacturers in the form of witnessing costs for type-approval.
Indirect costs (prices)				
			X	• **Costs for users of vehicles (both citizens and businesses users)** Regulatory costs to industry are expected to be passed down to consumers in the form of higher vehicle prices. Cost increase per vehicle in comparison to average vehicle prices: Increase of 2.7-4.3% for diesel LDV and 0.6-1.2% for petrol LDV (Euro 6d) Increase of 4.2-5.0% for lorries and 2.1-3.0% for buses
Direct benefits (environmental and health benefits)				
Compared to the estimates of the former Euro 6/VI impact assessment up until 2020: Euro 6: 24% savings of NOx resulting in 60-90% increase in health benefits. Euro VI: 37% savings of NOx and 22% of PM			**X**	High impact through reductions of emissions from a number of regulated pollutants up to 2020 and even higher level of reduction expected in the future. Emission savings up until 2020: NOx savings: 21.8% for Euro 6 and 35.7% for Euro VI Exhaust PM10 savings: 28% for Euro 6 and 13.5% for Euro VI THC savings: 20.5% for Euro 6 and 14% for Euro VI NMHC savings: 11.9% for Euro 6 Total monetised benefits up until 2020: For NOx: €28.5 billion for Euro 6 and €65.1 billion for Euro VI For PM: €2 billion for Euro 6 and €1.4 billion for Euro VI

				High confidence since calculations are based on best available information on emission savings, including generally accepted emission factors and factors to monetise external costs (handbook of external costs of transport).

2.2 Euro 7 impact assessment

Table 4 – Overview of direct and indirect benefits in the policy options (2025-2050)

I.A Overview of Benefits (total for all provisions for light- and heavy-duty vehicles) – Option 1		
Description	***Amount***	***Comments***
Direct benefits		
Regulatory costs savings: Testing, witnessing, type-approval and administrative costs savings	€3.88 billion	• Main recipients of the benefit: Automotive industry and eventually citizens through reduced vehicle prices
Health and environmental benefits	€43.50 billion	• Main recipient of the benefit: citizens
Indirect benefits		
Consumer trust	Low benefit	• Main recipient of the benefit: citizens

I.B Overview of Benefits (total for all provisions for light- and heavy-duty vehicles) – Option 2a		
Description	***Amount***	***Comments***
Direct benefits		
Regulatory costs savings: Testing, witnessing, type-approval and administrative costs savings	€3.83 billion	• Main recipients of the benefit: Automotive industry and eventually citizens through reduced vehicle prices
Health and environmental benefits	€187.36 billion	• Main recipient of the benefit: citizens
Indirect benefits		
Competitiveness: Access to international key markets	Low benefit	• Main recipient: automotive industry
Consumer trust	Moderate benefit	• Main recipient: citizens

I.C Overview of Benefits (total for all provisions for light- and heavy-duty vehicles) – Option 2b		
Description	***Amount***	***Comments***
Direct benefits		
Regulatory costs savings: Testing, witnessing, type-approval and administrative costs savings	€3.83 billion	• Main recipients of the benefit: Automotive industry and eventually citizens through reduced vehicle prices
Health and environmental benefits	€199.18 billion	• Main recipient of the benefit: citizens
Indirect benefits		
Competitiveness: Access to international key markets	Moderate benefit	• Main recipient: automotive industry

Competitiveness: Innovation	Low benefit	• Main recipient: automotive industry
Free movement within the single market	Low benefit	• Main recipient: automotive industry
Consumer trust	Moderate benefit	• Main recipient: citizens
Employment and skills	Low benefit	• Main recipient: citizens

I.D Overview of Benefits (total for all provisions for light- and heavy-duty vehicles) – Option 3a		
Description	***Amount***	***Comments***
Direct benefits		
Regulatory costs savings: Testing, witnessing, type-approval and administrative costs savings	€5.25 billion	• Main recipients of the benefit: Automotive industry and eventually citizens through reduced vehicle prices
Health and environmental benefits	€189.33 billion	• Main recipient of the benefit: citizens
Indirect benefits		
Competitiveness: Access to international key markets	Moderate benefit	• Main recipient: automotive industry
Competitiveness: Innovation	Moderate benefit	• Main recipient: automotive industry
Free movement within the single market	Low benefit	• Main recipient: automotive industry
Consumer trust	High benefit	• Main recipient: citizens
Employment and skills	Low benefit	• Main recipient: citizens

Table 5 – Overview of direct and indirect costs in the policy options

II.A Overview of costs for light- and heavy-duty vehicles – Option 1								
Billion €		**Citizens/Consumers**		**Manufacturers**		**Administrations**	
		One-off	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**
Simplification measures (cost savings see above)	Direct costs (regulatory costs)	0.00	0.00	0.00	-0.15	0.00	0.00
	Indirect costs (prices)	0.00	-0.15	0.00	0.00	0.00	0.00
Technology-neutral limits and low ambition real-driving testing[1]	Direct costs (regulatory costs)	0.00	0.00	3.19	0.23	0.00	0.00
	Indirect costs (prices)	0.00	0.35	0.00	0.00	0.00	0.00

[1] It is not possible to detangle costs for low ambition (technology-neutral Euro 6/VI) limits and boundaries, as it is one low-ambition emission control system.

II.B Overview of costs for light- and heavy-duty vehicles – Option 2 (including a and b)							
Billion €		**Citizens/Consumers**		**Manufacturers**		**Administrations**	
		One-off	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**
Simplification measures (cost savings see Table 4)	Direct costs (regulatory costs)	0.00	0.00	0.00	-0.15	0.00	0.00
	Indirect costs (prices)	0.00	-0.15	0.00	0.00	0.00	0.00
Medium ambition emission limits, real driving testing boundaries and durability (2a)[2]	Direct costs (regulatory costs)	0.00	0.00	16.30	1.32	0.00	0.00
	Indirect costs (prices)	0.00	1.94	0.00	0.00	0.00	0.00
High ambition emission limits, real driving testing boundaries and durability (2b)[2]	Direct costs (regulatory costs)	0.00	0.00	16.30	2.96	0.00	0.00
	Indirect costs (prices)	0.00	3.59	0.00	0.00	0.00	0.00

[2] It is not possible to detangle costs for medium ambition limits, boundaries and durability, as it is one medium-ambition emission control system. The same applies to the high-ambition emission control system.

II.C Overview of costs for light- and heavy-duty vehicles – Option 3a							
Billion €		**Citizens/Consumers**		**Manufacturers**		**Administrations**	
		One-off	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**	**One-off**	**Recurrent (annual)**
Simplification measures (cost savings see Table 4)	Direct costs (regulatory costs)	0.00	0.00	0.00	-0.20	0.00	0.00
	Indirect costs (prices)	0.00	-0.20	0.00	0.00	0.00	0.00
Medium ambition emission limits, real driving testing boundaries and durability (2a)[3]	Direct costs (regulatory costs)	0.00	0.00	16.30	1.32	0.00	0.00
	Indirect costs (prices)	0.00	1.94	0.00	0.00	0.00	0.00
Continuous emission monitoring	Direct costs (regulatory costs)	0.00	0.00	1.25	0.05	0.00	0.00
	Indirect costs (prices)	0.00	0.09	0.00	0.00	0.00	0.00

[3] It is not possible to detangle costs for medium ambition limits, boundaries and durability, as it is one medium-ambition emission control system.

Annex 4: Analytical methods and results

1. Description and results of methods and modelling tools

Since the evaluation and impact assessment are carried out in parallel through a "back-to-back" approach, the methods and modelling have been harmonised to ensure continuity and consistency. In both cases, models have been important for calculating and visualizing the future vehicle fleet and the related emission inventories. Cost models have been applied to calculate all the relevant costs and benefits to support the assessment of the impacts in Chapter 6 and 7 of the impact assessment.

COPERT is an internationally recognized and widely used tool for calculating greenhouse gas and air pollutant emission inventories for road transport based on real-world emissions coordinated by European Environment Agency (EEA) and by the JRC[31][32]. The COPERT methodology is part of the EMEP/EEA air pollutant emission inventory guidebook for the calculation of air pollutant emissions[33] and **is used by the large majority of European countries for reporting official emissions data**. The tool uses vehicle population, mileage, speed and other data (e.g. ambient temperature) to calculate emissions and energy consumption in a specific country or region. In particular, COPERT develops reliable and widely recognised emission factors that indicate the level of pollutant emissions released by a polluting activity

SIBYL was used to project the vehicle fleet. **SIBYL is a specialised tool for projecting the impact of detailed vehicle technology on future fleets, energy, emissions and costs designed to support policy making**. It has the ability to project emissions based on fleet dynamics, expected market trends and forecasted fleet growth scenario up to 2050. Based on these features and by utilising proper emission (see COPERT above*)* and consumption factors, SIBYL is able to project emission and energy evolutions from road vehicles. SIBYL is also the core calculation module of the JRC DIONE[34] model. The latter has a successful record of use in the Commission's transport, energy and climate impact assessments, including the CO_2 standards for light- and heavy-duty vehicles[35].

In addition and in order to maintain compatibility with other Commission policies and modelling, the SIBYL baseline was calibrated to the EU reference scenario from the PRIMES 2020 model[36], the main model used in the Commission's energy and climate policy assessments, and more specifically the 2030 climate target plan following the

[31] COPERT: The industry standard emissions calculator
[32] EEA, 2016. Copert 4
[33] EEA, 2019. EMEP/EEA air pollutant emission inventory guidebook
[34] JRC, 2017. Light Duty Vehicle CO2 emission reduction cost curves and cost assessment – the DIONE Model and JRC, 2018. Heavy duty vehicle CO2 emission reduction cost curves and cost assessment – enhancement of the DIONE model
[35] Regulation (EU) 2019/631 CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, Regulation (EU) 2019/1242 CO_2 emission performance standards for new heavy-duty vehicles
[36] E3 Modelling, 2020. The core PRIMES model

announcement of the Fit-for-55 Commission proposal[37].

In combination with the COPERT, the SIBYL[38] vehicle stock, activity and emission projection tool was used to estimate emission reductions until 2050 and compare them with the baseline, i.e. the "no policy change" scenario (see chapter 5.1). The SIBYL and COPERT model were updated with the data collected, latest emission factors that represent the quantity of a pollutant released to the atmosphere through a polluting activity and literature reviews in the supporting Euro 7 impact assessment study[39] and synchronised with the PRIMES 2020 vehicle stock and vehicle activity used for the revision of the CO_2 emission performance standards for new passenger cars and for new light commercial vehicles[40].

There is a close interaction between the models in the assessment. As shown in Figure 8, the output from SIBYL serves as input for both COPERT and the cost models. That way, the total emissions and associated technology costs can be calculated to support the analysis of the effectiveness and efficiency of the Euro 6/VI emission standards and the assessment of the impacts for a Euro 7 initiative.

In the context of the Euro 6/VI evaluation and Euro 7 impact assessment, the modelling tools and methods cover:

- The **broad vehicle categories**, including: cars, vans, lorries and buses and for each category a number of different segments. No distinction is made for small volume manufacturers.[41]
- A **broad range of fuel and powertrain vehicle technologies**, including: petrol, diesel, hybrids, LPG/CNG (bi-fuel), plug-in hybrids (PHEV), battery electric, fuel cell electric vehicle (hydrogen) and flexi-fuel (bioethanol).
- **Geography**: While the backward-looking evaluation of Euro 6/VI considers the dataset for the EU-27 countries and the United Kingdom, for the forward-looking impact assessment of the Euro 7 initiative the EU-27 data file was used for emission modelling. Hence, the geography of both assessments is limited to the EU market.[42]
- **Time horizon**:
    - evaluation of Euro VI: 2013-2050, Euro 6: 2014-2050

[37] COM(2020) 562 final, Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people

[38] SIBYL: Ready to go vehicle fleet, activity, emissions and energy consumption projections for the EU 28 member states

[39] CLOVE, 2022. Euro 7 Impact Assessment Study. ISBN 978-92-76-58693-7.

[40] SWD(2021) 613 final, Commission Staff Working Document, Impact Assessment, Accompanying the document Proposal for a Regulation amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition

[41] The contribution of small volume manufacturers (i.e. those with less than 10 000 vehicles produced worldwide annually) to the overall emissions from road transport is minimal since they only comprise less than 0.4 percent of total vehicle registrations in Europe each year. Moreover such vehicles travel far less km (around 3 700 km/year) (ESCA, 2021) than the average cars in Europe. The combined effect on emissions is therefore much less than 0.4% and can be considered as negligible. Any special provisions for such manufacturers will thus have negligible effect in the impacts of Euro 7 and are therefore not addressed in this impact assessment.

[42] Since the Euro standards are only applicable to vehicles sold in the EU and not to vehicles produced in the EU for other markets, exports are not considered in the cost-benefit analysis. Still, the indirect impact of Euro 7 policy options on competitiveness of EU manufacturers is assessed (see Annex 4 section 1.4.1).

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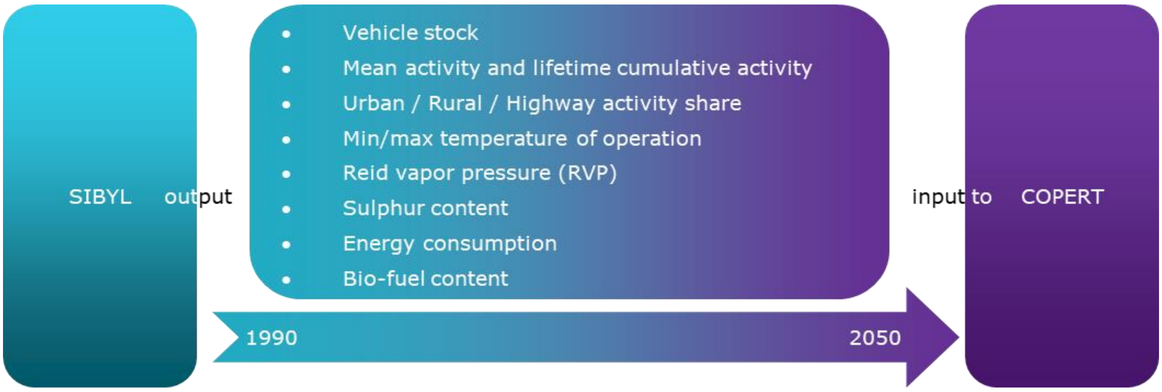
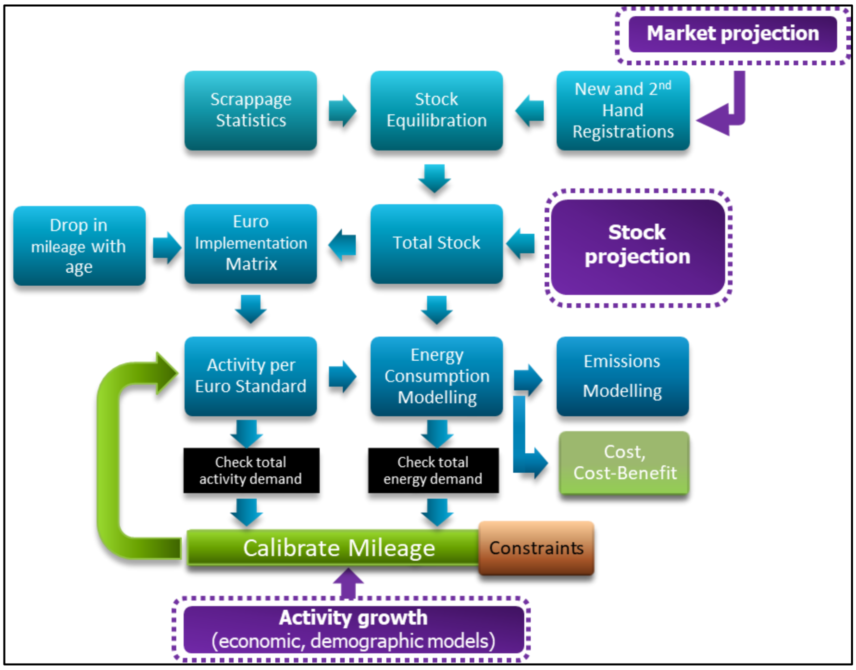
Figure 8 – Interlinkage between SIBYL and COPERT[43]



1.1. Fleet modelling with SIBYL

The process towards fleet modelling with SIBYL is illustrated in Figure 9. As a first step, the vehicle stock is balanced with the statistical data by taking into account the new registered vehicles (including used vehicles) and scrappage[44] statistics. Afterwards, the vehicles are classified in the various Euro emission standards on the basis of a "technology matrix" that connects the technology of new registrations with the year they entered into the fleet by taking into account the introduction date of each Euro standard. The annual mileage is then calibrated to ensure that the energy demand is consistent with the statistical energy consumption. **For the projected years, the stock and mileage are then calibrated in line with the activity growth described in the EU reference scenario from the PRIMES 2020 model.**

Figure 9 – Process for developing the SIBYL baseline[45]



[43] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.1 Introduction of COPERT/SIBYL tools
[44] Scrappage is the act of offering people money if they get rid of an old vehicle and buy a new one.
[45] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.2 Fleet modelling

The reliability, quality, completeness and consistency of the SIBYL tool and data are ensured by the high expertise of the developers in combination with an extensive level of reviewing and cross-checking. Next to that, the **SIBYL fleet data** takes into account a) the Euro 6/VI emission standards, b) the impact of COVID-19 on road transport activity[46] and c) the impact of the new 55% (cars) and 50% (vans) CO_2 targets by 2030 and 100% CO_2 targets for cars and vans by 2035[47] and the projected fit-for-55 HDV fleet evolution to contribute to the 55% net greenhouse gas emission reduction by 2030 and the 2050 climate neutrality objective[48]. Lastly, it has been harmonised with **official statistics from several official EU sources** (e.g., Eurostat, European Alternative Fuels Observatory). Table 6 gives an overview of these official sources and the main information provided, while also showing other sources used for the SIBYL fleet data. In the context of the work on the Euro 6/VI evaluation and the Euro 7 impact assessment, an effort was done to gather additional data directly from the Member States and research institutes. Bilateral consultations took place which were targeted at acquiring data on new vehicle registrations. These consultations led to the update of the datasets for a group of 10 Member States. While not covering all Member States, this group is found to have a rate of renewal of passenger cars which is close to the EU average.[49] Next to that, other relevant datasets on new registration[50] were used for cross-checking.

Table 6 – Overview data sources for the SIBYL fleet modelling, based on CLOVE, 2022[51]

Source	Main information provided
Official EU sources	
Eurostat[52]	Stock and new registrations per fuel and engine capacity / GVW
EC Statistical Pocketbook[53] (EU Transport in figures)	Stock and new registrations
CO_2 monitoring database[54]	New registrations per fuel and segment (PCs and LCVs)

[46] Road transport activity is the volume-km driven by vehicles on EU roads and is projected by the estimated evolution of vehicle sales.
[47] A linear interpolation was used for the year 2030 for both the activity and shares of vehicles between the two existing scenarios in the CO_2 Impact Assessment (TL_Med and TL_High), while the TL_High scenario was used for the year 2035. This approach is the estimated representation of the impact of the Commission proposal for CO_2 targets for cars/vans.
[48] For heavy–duty vehicles, the activity and fleet shares of vehicles are based on the SWD(2020) 176 final, Impact Assessment on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people (part 1) and SWD(2020) 176 final (part 2), supplemented for buses by CLOVE, 2022.
[49] See footnote 45
[50] See footnote 129
[51] See footnote 45
[52] Eurostat, 2021. New registrations of passenger cars by type of motor energy and engine size
[53] Publications Office of the EU,2019."EU transport in figures"
[54] EEA, 2020."Monitoring of CO2 emissions from passenger cars – Regulation (EU) 2019/631",2020

EAFO[55] (European Alternative Fuels Observatory)	Stock and new registrations of alternative fuels (LPG, NG, electric, H_2)
Other sources	
ACEA[56]	Stock per fuel, new registrations per fuel and per segment / GVW
ACEM[57]	Stock, new registrations per fuel and engine capacity (L-vehicles)
NGVA Europe[58] (Natural Gas Vehicle Association) / NGV Global[59] (Natural Gas Vehicle Knowledge Base)	Stock of natural gas vehicles
UNFCCC[60]	Fuel sold, based on Eurostat and disaggregated per vehicle category
Others: literature, studies, reports, national statistics web sites	Various information (level of detail is country-dependent)

SIBYL reflects the real situation to the extent possible and contains highly accurate emissions figures. The dataset of the SIBYL model covers the horizon from 1990 until 2050 and includes all Member States of the EU individually, as well as neighbouring and candidate countries. Hence, a complete and consistent transport dataset has been created and harmonised with official national statistics.

However, some issues have been identified with these data sources. None of these sources provided all the necessary data at the required level of detail and some gaps or incomplete time series (missing countries/years) were discovered. In addition, the collected information was sometimes found to be inconsistent with different sources presenting different values or vehicle classifications. In order to overcome such issues, a processing methodology has been developed to combine the primary information from various sources in order to produce total numbers for the vehicle fleet (for each vehicle category/fuel/segment). The different steps for ensuring that the outcome of the processing methodology is a complete and consistent dataset is explained in Box 1.

It is important that the SIBYL fleet data takes into account the age distribution of the fleet. To ensure better modelling of the fleet structure, technologies and the specific Euro standards per country, the average age of the vehicle category considered in the model must be consistent with statistical data. Therefore, the methodological steps summarized in Box 2 have been followed. The outcome of this phase is then an age distributions per fuel and segment for each vehicle category so that the checking rules in Box 1 are satisfied for all age bins[61]. Once the age distributions have been finalised, vehicles have been allocated to the different Euro emission standards based on the previously described technology matrices.

The consistency of the SIBYL fleet data with the national inventory submissions of fuel

[55] EAFO,2017.”The transition to a Zero Emission Vehicles fleet for cars in the EU by 2050”,2017
[56] ACEA, 2020. Consolidated registrations by country
[57] acem, 2021.
[58] NGVA Europe, 2021.
[59] NGV Global, 2021.
[60] UNFCC,2020, “National Inventory Submissions 2020”
[61] There are 30 age bins in the dataset: from age 0 (new registrations) to age 29. All stock vehicles are allocated to these bins, so that the sum of vehicles in all age bins equals to the total number of vehicles.

consumption data was checked for the different vehicle categories through the UNFCC[62]. Subsequently, micro-adjustments have been made in the mileage of the vehicles in order to match the calculated fuel consumption with the statistical one.

Box 1 – Data processing methodology for SIBYL fleet data[63]

- Comparison of the source – one data source is selected as the main source (based on data quantity and quality).
- Gap-filling based on other sources taking into account possible inconsistencies. For example, in case of significant differences between two sources, the relative trend is considered instead of the absolute value.
- If gaps remain, these are filled in based on: 1) Interpolation, 2) Relative trend or data from another country (e.g. percentages for split/disaggregation), 3) Estimates and expert judgement calculations.
- As a last step, some checks are performed based on the following questions (i.e. checking rules):
    - Do all fuels add up to the total?
    - Do all segments of a fuel add up to this specific fuel?
    - Are there no negative values?
    - Do all percentages add up to 100%?

Box 2 – Methodological steps for determining the fleet's age distribution[64]

- An estimate was made for the age distribution in 1990 based on the new registrations of this year and expert judgement.
- The age distribution for the following years have been derived using lifetime functions, which model the ages at which vehicles are deregistered from the fleet.
- Then, modifications were made in the age distribution, by internal "transferring" of vehicles among age groups to ensure coherence with the statistical average age data (from the different sources in Table 6).
- This results in an age distribution for the total stock which has been used as a guide to produce age distributions per fuel and segment, taking into account the characteristics of individual vehicle subcategories. For example:
    - Many LPG vehicles are conversions from petrol vehicles, not actual sales.
    - The age distribution for electric vehicles is expected to be completely different compared to conventional vehicles, as the former only entered the fleet recently.
    - Differentiations in the age distribution for petrol and diesel vehicles which has been driven by past sales patterns. That way, the petrol fleet is currently older than the diesel fleet.

1.2. Emissions modelling with COPERT

1.2.1. Emission factors

To calculate the environmental benefits in both the Euro 6/VI evaluation and Euro 7 impact assessment, the total annual emissions have to be analysed. The general scheme for calculating the emissions of a pollutant for a specific vehicle category and year is presented in the equation below.

Equation 1[65] $E_{p,j,x} = N_{j,x} \times M_{j,x} \times EF_{p,j,x}$

[62] See footnote 60

[63] See footnote 45

[64] See footnote 45

[65] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.4.1 Emissions modelling: overall methodological approach

Where

- E = total annual emissions
- N = number of vehicles in operation
- M = annual mileage per vehicle
- EF = estimated emission factor in g/km
- p = air pollutant or greenhouse gas
- j = vehicle category
- x = year of calculation

While the first two elements of the calculation (i.e. N and M) are a direct output from the SIBYL fleet modelling discussed in the previous chapter, the sources for finding the emission factors ($EF_{p,j,x}$) differs for the Euro standard vehicle technologies. The evaluation, which considers the different steps of Euro 6 and Euro VI, could mostly rely on the COPERT model for determining the emission factors. However, for the latest steps in Euro 6 – Euro 6d-temp and Euro 6d – other sources were consulted.[66] Also for the policy options in the impact assessment, different emission factor sources had to be considered in the supporting impact assessment study[67] to take into account future technologies and assess their environmental impact which were included in the last version of the COPERT model v5.4. The first update includes the revision of emission factors for Euro 5 vehicles in order to be in line with the latest information on defeat devices. This revision is expected to influence the current emissions benefits of Euro 6 over Euro 5 and was performed after screening with the Handbook Emission Factors for Road Transport (HBEFA 4.1)[68]. This handbook was originally developed on behalf of the Environmental Protection Agencies of Germany, Switzerland and Austria. Over the years, further countries as well as the JRC are supporting the HBEFA. The handbook provides emission factors for all current vehicle categories for a wide variety of traffic situations, while covering all regulated and the most important non-regulated pollutants.[69]

Moreover, the emission factors for all Euro 5 - V and Euro 6 a/b/c - VI A/B/C technologies were re-calculated in order to take into account the effect of driving conditions outside the current RDE boundaries, including the effect of cold-start, the operation under hot conditions, the degradation of emission control systems due to high mileage or age, as well as the impact of tampering and malfunctions not detected by OBD.

For cars and vans using the latest technology (Euro 6d-temp and Euro 6d), an emission performance analysis has been conducted. In order to assess the emission levels of these vehicles and to support the update of the existing databases for emission factors, emission data from more than 500 tests from a pool of 45 vehicles were collected and analysed. Data sources from nine partners have been consulted, including CLOVE, JRC, H2020 projects and stakeholders. That way, these detailed data could be used over the other models (COPERT, HBEFA and VERSIT[70]) to achieve a higher accuracy for the

[66] CLOVE, 2022. Euro 6/VI Evaluation Study. Annexes 1:6 ISBN 978-92-76-56522-2, Chapter 9.3 Annex 3: Euro 6/VI SIBYL/COPERT model data
[67] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.4.2 Emission Factors (EFs) calculation/modelling
[68] Handbook emission factors for road transport (HBEFA), 2020.
[69] See footnote 68
[70] TNO, 2007. VERSIT+ state-of-the art road traffic emission model.

emission factors. For lorries and buses, input on the emission factors of Euro VI D/E vehicles was derived from HBEFA, while experimental data provided by CLOVE were used for calculating emission factors under test conditions not covered by HBEFA (e.g. in terms of trip characteristics or composition).[71]

When it came to emission factors for future technologies following future possible legislation, the current models fell somewhat short. Therefore, scenarios were created for the policy options, resulting in corresponding estimated emission factors.

In general, emission factors of the various pollutants for each vehicle category depend on many parameters, including driving patterns, environmental conditions, road gradient and the level of maintenance of the vehicle (e.g. cold versus hot temperatures, evaporation, degradation, tampering, malfunction etc.). To control for this, components or emission processes related to such parameters and their individual effects on vehicle emissions are considered separately to estimate the impact of the different policy options. That way, only relevant parts of the emission factor will be affected when a new policy action is introduced in the simulations. For example, if new requirements on On-Board Diagnostics (OBD) were to be introduced, only the component on malfunctions will be affected and not the base emission factor.

This is summarized in the following equation, which represents the general scheme for calculating emissions factors.

Equation 2[72]

$$EF = [(w_1 EF_{hotRDE} + w_2 EF_{hotNonRDE}) \times DF(M) + w_1 EF_{coldRDE} + w_2 EF_{coldNonRDE}] \times (1 - Tamp.share) + (w_1 EF_{hotRDE} + w_2 EF_{hotNonRDE}) \times (Tamp.share) \times (Tamp.rate)$$

Where:

- w1: fraction of mileage to RDE conditions
- w2: fraction of mileage to non RDE conditions (w2 = 1 - w1)
- hotRDE: hot mean emission level over RDE driving
- hotNonRDE: hot mean emission level outside of RDE (incl. AES)
- coldRDE: cold mean emission level over RDE driving
- coldNonRDE: cold mean emission level over RDE driving
- DF(M): deterioration factor of emission at mean fleet mileage (M)
- Tamp.share : % of tampered vehicles
- Tamp.rate: tampering emission rate (tampered/ok)

The above equation decomposes the final emission factor into the various components that are meaningful for the purpose of the impact assessment on the different policy options. Every term in Equation 2 is calculated in a separate modeling activity based on the available data (more information on these separate modeling activities can be found in the supporting impact assessment study Annex 1)[73].

The emission factors for each pollutant considered in the Euro 6/VI evaluation are presented in Table 7.

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[71] See footnote 65; and CLOVE, 2022. Technical studies for the development of Euro 7. Testing, Pollutants and Emission Limits. ISBN 978-92-76-56406-5.
[72] See footnote 65
[73] See footnote 65

Table 7 – Emission factors for the different pollutants used in the evaluation baseline and under the different steps of Euro 6/VI[74] (*Average ± standard deviation, mg/km)*

	Diesel cars and vans				Petrol cars and vans			
	Euro 5	**Euro 6 a-c**	**Euro 6d-temp**	**Euro 6d**	**Euro 5**	**Euro 6 a-c**	**Euro 6d-Temp**	**Euro 6d**
NO_x	1 204.37 ± 88.78	656.65 ± 95.40	148.14 ± 14.10	127.57 ± 2.35	58.11 ± 1.34	43.11 ± 1.41	22.92 ± 1.55	20.66 ± 0.20
PM_{total}	26.98 ± 2.30	23.34 ± 2.46	23.00 ± 2.20	21.50 ± 0.68	21.38 ± 2.09	20.37 ± 2.15	19.34 ± 2.21	18.84 ± 0.03
$PM_{exhaust}$	4.88 ± 0.00	1.17 ± 0.10	0.45 ± 0.00	0.43 ± 0.01	2.37 ± 0.02	1.40 ± 0.06	0.34 ± 0.00	0.32 ± 0.01
CO	82.03 ± 5.22	74.75 ± 15.76	77.31 ± 13.47	61.15 ± 4.84	2 949.56 ± 204.73	1. 55.45 ± 79.61	582.26 ± 59.93	513.24 ± 15.85
THC	20.70 ± 0.00	19.21 ± 4.16	20.18 ± 3.71	16.20 ± 1.86	1 714.87 ± 2.897.72	1 667.61 ± 2.956.09	781.70 ± 1.440.61	96.11 ± 4.24
NMHC	2.61 ± 0.00	2.37 ± 0.42	2.47 ± 0.37	2.06 ± 0.18	1 694.22 ± 2 897.11	1 648.51 ± 2 956.23	777.30 ± 1 440.45	91.23 ± 3.92

	Lorries and buses	
	Euro V	**Euro VI**
NO_x	9 090.69 ± 170.38	2 014.95 ± 407.06
PM_{total}	124.28 ± 1.97	92.63 ± 11.48
$PM_{exhaust}$	65.47 ± 1.10	33.78 ± 9.34
CO	2 761.01 ± 45.71	224.00 ± 129.11
THC	61.18 ± 0.97	32.39 ± 7.54
NMHC	60.06 ± 0.95	31.75 ± 7.41
NH_3	12.49 ± 0.24	22.35 ± 1.18
CH_4	1.13 ± 0.02	0.63 ± 0.14

Table 8 presents the four sets of emission factors which are used in the impact assessment baseline to calculate the emission savings. This set of conservative emission factors reflects the limitation of available measurement data and a worsening of today's measured emission levels in the future[75]:

- Current data mostly contains results from vehicles of the higher segments that often contain expensive emission control systems. It has been shown that vehicles at lower segments are generally not equipped with such sophisticated systems thus exhibiting higher emissions over certain operation conditions.

- Current data is still limited and shows a significant range[76]. Maximum values should be taken into account by manufacturers to demonstrate compliance with emission limits.

- The trade-offs between CO_2 and air pollutants (primarily NO_x) could potentially push vehicle manufacturers to relax NO_x control to benefit CO_2 to reach the new and more

[74] See footnote 190
[75] Supporting Euro 7 impact assessment study, chapter 4.1 Baseline development without introduction of a new emission standard
[76] For example, the 33 RDE compliant tests of Euro 6d diesel cars by JRC, TNO and GreenNCAP comprise 26 diesel cars without diesel particulate filter (DPF) regeneration with in average 33 mg NOx/km (7-116 mg NOx/km) and 7 diesel cars with DPF regeneration with in average 58 mg NOx/km (18-136 mg NOx/km).

ambitious CO_2 emission standards. This is a behaviour observed in the past with each new emission standard. Example is the recent increase in PN emissions from port-fuel injection gasoline vehicles with the introduction of Euro 6 PN limit which did not apply for these vehicles in order to better control other regulated emissions.

- As manufacturers gain experience in calibration and optimisation of the emission control system while also improvements in the measuring techniques are made, this can enable a decrease in the margin of safety over the limit value.

All these factors may contribute to higher real-world emission levels and an increase in the real-world average emission levels of new registrations with time. Since such a trend is not uncommon and has been observed in the past, this approach of conservative Euro 6/VI emission factors was taken.[77]

Table 8 – Average emission factors (EF) for the different pollutants under the impact assessment baseline[78]

A) Cars and vans – Euro 6d (-temp) (in mg/km or #/km for PN_{10})

	NO_x	CO	PM	PN_{10}	THC	CH_4	NH_3	N_2O
Hot EFs for RDE driving								
Petrol	10.2	186.6	0.160	7.6E+11	5.1	2.4	11.3	0.3
Diesel	33.1	31.6	0.150	3.3E+10	12.8	11.5	0.3	12.4
CNG	10.2	186.6	0.080	3.5E+11	37.7	20.8	11.3	0.3
Hot EFs for outside RDE driving								
Petrol	22.1	1202.6	0.450	1.1E+12	5.1	2.4	11.3	0.3
Diesel	190.9	43.4	0.375	1.4E+11	12.8	11.5	0.3	12.4
CNG	22.1	1202.6	0.225	7.0E+11	37.7	20.8	11.3	0.3
Excess Cold EFs for RDE driving								
Petrol	5.0	75.0	0.090	2.8E+11	17.1	1.2	1.2	0.5
Diesel	12.5	17.2	0.120	1.3E+10	0.6	0.1	0.0	0.6
CNG	5.0	75.0	0.045	2.0E+11	17.5	9.3	1.2	0.5
Excess Cold EFs for outside RDE driving								
Petrol	21.2	250.8	0.170	5.9E+11	17.1	1.2	1.2	0.5
Diesel	54.4	19.5	0.310	9.6E+09	0.6	0.1	0.0	0.6
CNG	21.2	250.8	0.085	1.9E+11	17.5	9.3	1.2	0.5

[77] For example, the first set of emission factors for Euro 6a/b vehicles developed by the ERMES group was based on vehicles of higher segments and was actually lower than subsequent revisions which also used data from lower segments. See also Keller, M. 2013. HBEFA Status Report ERMES Meeting Sept. 2013.
[78] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.4 Emissions modelling

B) Lorries and buses – Euro VI D/E (in g/kWh or #/kWh for PN)

EF	HDV type	Driving mode	NO_x	PM	PN	THC	NH_3	N_2O	CH_4	CO
Hot RDE	Long haul lorries	Urban hot	0.377	0.0087	9.01E+10	0.0148	0.015	0.235	0.00038	0.060
		Rural	0.128	0.0042	4.12E+10	0.0083	0.012	0.160	0.00016	0.035
		Motorway	0.021	0.0036	4.05E+10	0.0073	0.012	0.128	0.00015	0.028
	Rigid lorries	Urban hot	0.377	0.0087	9.01E+10	0.0148	0.015	0.235	0.00038	0.060
		Rural	0.128	0.0042	4.12E+10	0.0083	0.012	0.160	0.00016	0.035
		Motorway	0.021	0.0036	4.05E+10	0.0073	0.012	0.128	0.00015	0.028
	Urban buses	Urban hot	0.377	0.0087	9.01E+10	0.0148	0.015	0.235	0.00038	0.060
		Rural	0.128	0.0042	4.12E+10	0.0083	0.012	0.160	0.00016	0.035
		Motorway	0.021	0.0036	4.05E+10	0.0073	0.012	0.128	0.00015	0.028
Hot outside RDE	Long haul lorries	-	8.20	0.0137	1.41E+11	0.0551	0.015	0.051	0.00144	0.216
	Rigid lorries	-	8.20	0.0137	1.41E+11	0.0551	0.015	0.051	0.00144	0.216
	Urban buses	-	8.20	0.0137	1.41E+11	0.0551	0.015	0.051	0.00144	0.216
Excess Cold start	Long haul lorries	-	12	0.1	6.00E+11	0.25	0.012	5.25	0.013	1.85
	Rigid lorries	-	6.36	0.027	3.18E+11	0.1326	0.006	2.78	0.007	0.980
	Urban buses	-	8.73	0.036	4.36E+11	0.1818	0.009	3.82	0.009	1.34

C) Brake emissions (in mg/km)

Vehicle category	$PM_{2,5}$ from brakes	PM_{10} from brakes
Cars	4.37	11
Vans	7.71	19.4
Lorries	11.3 - 11.8	28.5 - 29.5
Buses	11.1 - 19.7	27.9 - 49.6

The emission factors for the different policy options are presented in Table 9. It is important to note that the emission levels in PO2a/PO3a and PO2b are extremely low and only differ with regard to the excess cold emission factors, while the hot emission factors are assumed to be the same leading to overall small emission levels in PO2a/PO3a and PO2b.

Table 9 -Average emission factors for the different pollutants in the policy options[79]

A) Cars and vans (in mg/km or #/km for PN_{10})

Policy option (PO)	Fuel	NO_x	CO	PM	PN_{10}	THC	CH_4	NH_3	N_2O
	Hot EFs for RDE driving								
PO1	Petrol	10.2	186.6	0.160	7.6E+11	5.1	2.4	11.3	0.3
	Diesel	33.1	31.6	0.150	3.3E+10	12.8	11.5	0.3	12.4
	CNG	10.2	186.6	0.080	3.5E+11	37.7	20.8	11.3	0.3
PO2a. PO3a	Petrol	1.6	33.9	0.151	9.6E+09	0.3	2.4	5.3	0.3
	Diesel	3.0	31.6	0.135	1.1E+10	6.5	5.2	0.3	12.4
	CNG	1.6	33.9	0.076	3.8E+10	0.3	20.8	5.3	0.3
PO2b	Petrol	1.6	33.9	0.151	9.6E+09	0.3	2.4	5.3	0.3
	Diesel	3.0	31.6	0.135	1.1E+10	6.5	5.2	0.3	6.6
	CNG	1.6	33.9	0.076	3.8E+10	0.3	20.8	5.3	0.3
	Hot EFs for outside RDE driving								
PO1	Petrol	22.1	1.203	0.450	1.1E+12	5.1	2.4	11.3	0.3
	Diesel	100.5	43.4	0.375	1.4E+11	12.8	11.5	0.3	12.4
	CNG	22.1	1203	0.225	7.0E+11	37.7	20.8	11.3	0.3
PO2a. PO3a	Petrol	4.2	114.9	0.435	3.4E+10	0.8	2.4	5.6	0.3
	Diesel	10.0	43.4	0.314	6.3E+10	6.5	5.2	0.3	12.4
	CNG	4.2	114.9	0.217	1.4E+11	0.8	20.8	5.6	0.3
PO2b	Petrol	4.2	114.9	0.435	3.3E+10	0.8	2.4	5.6	0.3
	Diesel	10.0	43.4	0.314	6.3E+10	6.5	5.2	0.3	6.6
	CNG	4.2	114.9	0.217	1.3E+11	0.8	20.8	5.6	0.3

[79] See footnote 78

PO	Fuel	NO_x	CO	PM	PN_{10}	THC	CH_4	NH_3	N_2O
	Excess Cold EFs for RDE driving								
PO1	Petrol	5.0	75.0	0.090	2.8E+11	17.1	1.2	1.2	0.5
	Diesel	12.5	17.2	0.120	1.3E+10	0.6	0.1	0.0	0.6
	CNG	5.0	75.0	0.045	2.0E+11	17.5	9.3	1.2	0.5
PO2a. PO3a	Petrol	4.5	73.3	0.089	3.7E+10	10.1	1.2	0.6	0.5
	Diesel	3.0	17.2	0.115	4.5E+09	0.2	0.1	0.0	0.6
	CNG	4.5	73.3	0.044	1.5E+11	10.1	9.3	0.6	0.5
PO2b	Petrol	3.3	59.0	0.089	3.7E+10	6.8	1.2	0.6	0.5
	Diesel	2.4	17.2	0.115	4.5E+09	0.2	0.1	0.0	0.4
	CNG	3.3	59.0	0.044	1.5E+11	6.8	9.3	0.6	0.5
	Excess Cold EFs for outside RDE driving								
PO1	Petrol	21.2	250.8	0.170	5.9E+11	17.1	1.2	1.2	0.5
	Diesel	35.1	19.5	0.310	9.6E+09	0.6	0.1	0.0	0.6
	CNG	21.2	250.8	0.085	1.9E+11	17.5	9.3	1.2	0.5
PO2a. PO3a	Petrol	21.2	105.1	0.170	6.3E+10	17.1	1.2	0.6	0.5
	Diesel	12.9	19.5	0.306	4.4E+09	0.6	0.1	0.0	0.6
	CNG	21.2	105.1	0.085	1.9E+11	17.5	9.3	0.6	0.5
PO2b	Petrol	21.2	90.8	0.170	5.8E+10	17.1	1.2	0.6	0.5
	Diesel	10.2	19.5	0.306	4.4E+09	0.6	0.1	0.0	0.4
	CNG	21.2	90.8	0.085	1.9E+11	17.5	9.3	0.6	0.5

B) Lorries and buses (in g/kWh or #/kWh for PN)

PO	Driving mode	NO_x	PM	PN	THC	NH_3	N_2O	CH_4	CO
	Hot EFs for RDE driving								
PO1	Urban hot	0.377	0.0087	9.01E+10	0.0148	0.015	0.235	0.00038	0.060
	Rural	0.128	0.0042	4.12E+10	0.0083	0.012	0.160	0.00016	0.035
	Motorway	0.021	0.0036	4.05E+10	0.0073	0.012	0.128	0.00015	0.028
PO2a. PO3a	Urban hot	0.009	0.0028	2.88E+10	0.0019	0.005	0.082	0.00038	0.018
	Rural	0.007	0.0013	1.32E+10	0.0010	0.004	0.056	0.00016	0.010
	Motorway	0.005	0.0012	1.30E+10	0.0009	0.004	0.045	0.00015	0.008
PO2b	Urban hot	0.009	0.0028	2.88E+10	0.0026	0.005	0.082	0.00038	0.018
	Rural	0.007	0.0013	1.32E+10	0.0014	0.004	0.056	0.00016	0.010
	Motorway	0.005	0.0012	1.30E+10	0.0013	0.004	0.045	0.00015	0.008
	Hot EFs for outside RDE driving								
PO1		8.20	0.0137	1.41E+11	0.0551	0.015	0.051	0.0014	0.216
PO2a. PO3a		0.178	0.0035	3.63E+10	0.0046	0.005	0.018	0.0010	0.068
PO2b		0.124	0.0035	3.63E+10	0.0058	0.005	0.018	0.0009	0.060

PO	HDV	NO_x	PM	PN	THC	NH_3	N_2O	CH_4	CO
	Excess Cold EFs for inside and outside RDE driving								
PO1	Long haul lorries	12	0.050	6.00E+11	0.250	0.012	5.25	0.013	1.85
	Rigid lorries	6.36	0.0265	3.18E+11	0.1326	0.006	2.784	0.0066	0.980
	Urban buses	8.73	0.0364	4.36E+11	0.1818	0.009	3.818	0.0091	1.344
PO2a. PO3a	Long haul lorries	2.38	0.002	2.40E+10	1.182	0	0.693	0.330	25.23
	Rigid lorries	1.26	0.0011	1.27E+10	0.6266	0	0.368	0.175	13.38
	Urban buses	1.73	0.0015	1.75E+10	0.8593	0.0	0.504	0.240	18.35
PO2b	Long haul lorries	0.853	0.002	2.40E+10	0.615	0	0.693	0.285	12.53
	Rigid lorries	0.452	0.0011	1.27E+10	0.3260	0	0.368	0.151	6.64
	Urban buses	0.620	0.0015	1.75E+10	0.4471	0.0	0.504	0.208	9.11

C) **Brake emissions (in mg/km)**

PO	Vehicle category	$PM_{2,5}$ from brakes	PM_{10} from brakes
PO1	Cars	4.37	11
	Vans	7.71	19.4
	Lorries	11.3 - 11.8	28.5 - 29.5
	Buses	11.1 - 19.7	27.9 - 49.6
PO2a, PO3a	Cars	2.8	7.0
	Vans	4.9	12.3
	Lorries	11.3 - 11.8	28.5 - 29.5
	Buses	11.1 - 19.7	27.9 - 49.6
PO2b	Cars	2.0	5.0
	Vans	3.5	8.8
	Lorries	11.3 - 11.8	28.5 - 29.5
	Buses	11.1 - 19.7	27.9 - 49.6

1.2.2. Damage costs

Based on the emissions factors, the environmental benefits in the form of emissions savings can be calculated as an accumulated difference over the baseline over time. Since emission savings are a form of prevented pollution which could have negative effects on human health and environment, these savings create a benefit when expressed in monetised terms. This monetised health and environmental benefit (in €) has been calculated by multiplying the emission savings with the external damage costs per tonne of pollutant for each examined pollutant based on the handbook on the external costs of transport[80] (hereafter "the Handbook"). While the Handbook includes 2016 values, the Euro 6/VI evaluation and Euro 7 impact assessment are based on 2020 values by taking into account the annual inflation in the Member States.[81] The final damage costs were calculated as the weighted average of the Member States' damage costs over the activity of each Member State. Box 3 summarises the four types of impacts caused by road transport emissions resulting in damage costs according to Annex C.2 of the Handbook[82].

Box 3 – Impacts by air pollutants from road transport emissions based on the handbook

80 European Commission, 2019. Handbook on the external costs of transport
81 Eurostat, 2021. HICP – monthly data
82 See footnote 80

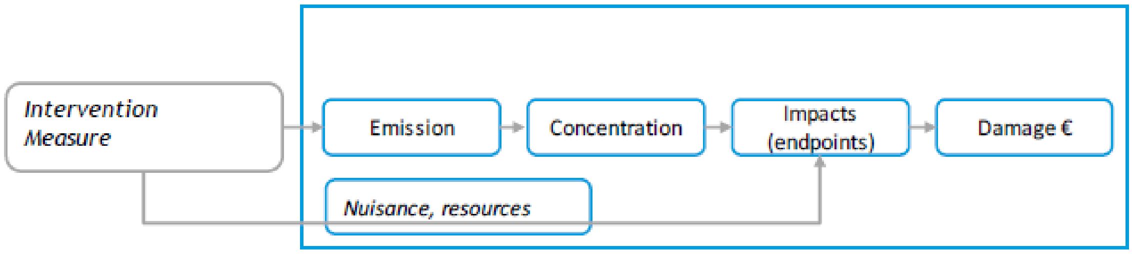
on the external costs of transport (2019)[83][84]

- **Health effects:** The inhalation of air pollutants - such as particles and NO_x - leads to a higher risk of respiratory diseases (e.g. bronchitis, asthma, lung cancer) and cardiovascular diseases. These negative health effects lead to medical treatment costs, production loss at work (due to illness) and even to death.
- **Crop losses:** As a secondary air pollutant, primarily caused by the emissions of NOx and VOC, ozone together with other acidic air pollutants (e.g. NOx) can damage the agricultural crops. Therefore, higher concentrations of these pollutants can result in a lower crop yield.
- **Material and building damage:** Emissions of air pollutants can damage buildings and other materials through two different mechanisms: a) Pollution of building surfaces through particles and dust; b) Damage of building facades and materials due to corrosion processes caused by acidic substances (e.g. NOx).
- **Biodiversity loss:** Air pollution can lead to damage of ecosystems. The acidification of soil, precipitation and water and the eutrophication of ecosystems are of most concern in this context. Such damages at ecosystems can lead to a decrease in biodiversity (fauna, flora).

The steps for the calculation of the damage costs are illustrated in Figure 10. This diagram shows how transport emissions[85] are released in the atmosphere of other regions increasing these respective concentrations. Subsequently, this leads to changes in 'endpoints' relevant to human welfare. These changes can be monetarily valued by quantifying the amount of damage caused at the endpoints.

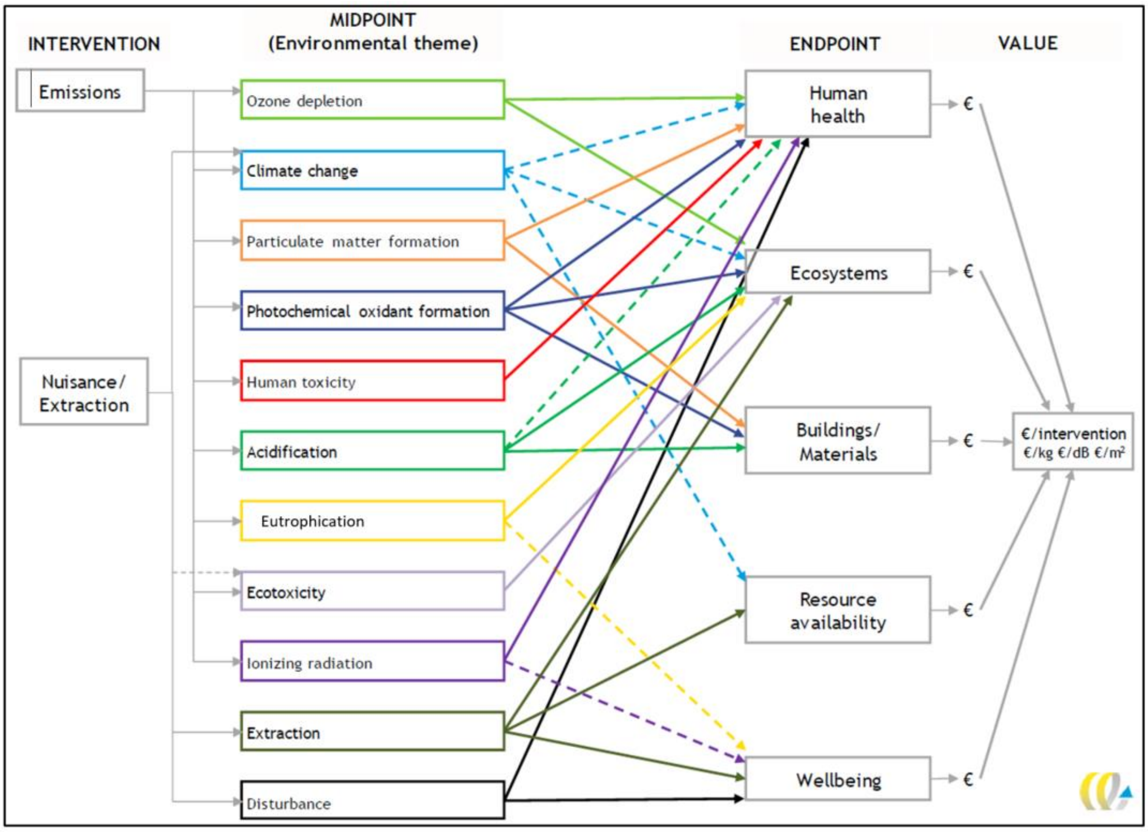
While Box 3 illustrated that vehicle emissions result in damage to a variety of endpoints through different interactions or midpoints, Figure 11 reflects the relationship between intervention, midpoints, endpoints and values as reported in the Environmental Prices Handbook[86]. An intervention would have an effect on certain environmental themes – midpoints – which would have an impact on the third level of the scheme: the endpoint representing the broader topics discussed in Box 3. The impact of the intervention at the endpoints is then represented by the impacts at each endpoint, calculated as damage costs.

Figure 10 – Calculation of damage costs[87]



[83] See footnote 80
[84] Since damage costs of N2O and CH_4 as air pollutant are not available, damage costs of N2O and CH4 are monetised as greenhouse gases. The Handbook monetises climate change costs from road transport as the costs associated with all of the effects of global warming, such as sea level rise, biodiversity loss, water management issues, more and more frequent weather extremes and crop failures.
[85] In this diagram, emissions refer to air pollutants, and not to emissions to soils or water occurred by tyre wear. As it is not yet feasible to develop limits or tests for tyre emissions, it is suggested to include a review clause in Euro 7.
[86] S. de Bruyn, M. Bijleveld, L. et al., 2018. Environmental Prices Handbook: EU-28 version (CE Delft)
[87] See footnote 80

Figure 11 - Relationships between interventions, midpoints, endpoints and valuation of environmental policies[88]



In order to estimate the damage costs per vehicle-kilometre (vkm) activity for different vehicle categories, the Handbook uses the emission data from the COPERT model. Costs are calculated to monetise the health and environmental impacts while taking into account concentration-response functions, population size and structure, population density, the relationship factors between damage and emissions for various emission scenarios and the most recent valuation of human health. Table 10 gives an overview of the damage costs for the pollutants that were considered in the monetisation scheme based on the respective area where the vehicle activity took place. The Handbook, however, does not cover the contribution of harmful NMHC (i.e. NMVOC) emissions to the formation of secondary organic aerosols.[89] Hence, information on the damage costs related to this phenomenon have been collected from other sources.[90][91] In addition, the damage costs are classified based on the area where a vehicle activity is considered to take place. In the calculation for the cost-benefit analysis, the activity was obtained from COPERT.

[88] See footnote 86

[89] While the damage costs for CH_4 and N_2O are considered through their global warming potential later in the text, CO and THC are not taken into account as no damage costs information is available in the Handbook for these pollutants.

[90] Such as: Lu Q., Zhao Y., Robinson A.L., 2018. “Comprehensive organic emission profiles for gasoline, diesel, and gas-turbine engines including intermediate and semi-volatile organic compound emissions”; and He Y., et al., 2020. “Secondary organic aerosol formation from evaporated biofuels: comparison to gasoline and correction for vapor wall losses”.

[91] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.4.5 Emission benefits

Table 10 - Damage costs for air pollutants for transport[92]

Pollutant	NO_x		NH_3	NMHC			$PM_{2.5}$ (both exhaust and non-exhaust)		
Area	City	Rural	All areas	Metro-politan*	City	Rural**	Metro-politan*	City	Rural**
Damage cost [€/kg]	24.5	14.5	19.5	3.41	2.06	1.78	401	132	76

*** Only for cities/agglomeration with > 0.5 million inhabitants ** Outside cities**

In order to perform the Cost-Benefit Analysis (see Chapter 1.3.), the described benefits were transformed into monetary values. The respective calculation takes into account the weighted averages of the activity shares of the different vehicle categories, weighted over the activity (in km/year) of the different categories and taking into account fleet composition data, in order to split the emissions based on the vehicle activity in urban, rural and highway traffic conditions, as included in COPERT. As an example, the equation for calculating the monetary benefits for NO_x is presented below. Similar equations were established for calculating monetary benefits from NH_3, NMHC and $PM_{2,5}$ are included in the supporting impact assessment study.[93] The total monetised benefit are then calculated as the sum of all the pollutant-specific monetised benefits.

In line with the WHO approach on health impacts from pollution[94] and the Handbook on the external costs of transport, the benefits of reducing emissions are independent of the absolute emission levels. This means that health benefits of decreasing NO_x emission by 1 ton is the same regardless of whether the concentration of the pollutant is low or high. The exposure of citizens to these concentrations, however, is of great importance. Therefore, Table 10 separates damage costs in metropolitan areas, urban areas and rural areas transport. Hence, emission reductions in a metropolitan area this will lead to larger health benefits than if this is decreased by the same amount in a rural area. This follows from the fact that more people will be affected in the dense metropolitan environment compared to the sparsely populated rural environment.

Equation 3[95]

$$NO_x[€] = NO_x[t] * \left(NO_{x,\ city}[€/t] * share_{urban}[\%] + NO_{x,\ rural} * [€/t]\left(share_{rural}[\%] + share_{highway}[\%]\right)\right)$$

Where:

- $NO_x[€]$ indicates the resulting monetized benefits
- $NO_x[t]$ indicates the emission saving calculated from COPERT
- $NO_{x,\ city}[€/t]$ indicate the damage/avoidance costs presented in Table 10
- $share_{urban/rural/highway}$ expressed in [%] indicate the respective vehicle activity obtained from the COPERT

[92] See footnote 68
[93] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.4.6 Calculation of monetised benefits
[94] WHO, 2013. Health risks of air pollution in Europe – HRAPIE project
[95] See footnote 93

1.2.3. Environmental impacts

1.2.3.1. Environmental impacts in policy option 1

The environmental impacts in terms of air pollutant emission reductions from road transport are the emission savings that would be achieved over the savings expected in the baseline with merely Euro 6/VI vehicle fleet renewal in combination with the impact of the new CO_2 standards.

As shown in Table 11, the overall emission savings that can be expected in policy option 1 are rather limited. Reason for this being that next to the introduction of low ambition extended real-driving conditions covering conditions outside the current RDE or PEMS boundaries and improved OBD to enable more effective ISC and MaS over the lifetime of vehicles, the emission limits are not really reduced, but only made technology-neutral.

For cars and vans, NO_x emissions are expected to further decrease compared to the baseline by 13% in 2030 to 55% in 2050. This decrease follows from the introduction of extended real-driving testing covering conditions outside the current RDE boundaries and a technology-neutral NO_x emission limit of 60 mg/km for cars, which replaces the current diverging NO_x limits in the Euro 6 standard of 60 mg/km for petrol cars and 80 mg/km for diesel cars.

Some savings can be expected for particles, NH_3 and CO emissions from cars and vans compared to the baseline. $PM_{2,5,exhaust}$ emissions are expected to decrease by 4% in 2030 to 29% in 2050, due to the increased use of improved particle filters and shift to electric vehicles, whereas $PM_{2,5,total}$ is not expected to decrease as option 1 does not include limits for unregulated brake and tyre emissions. PN emissions are expected to decrease by 5% in 2030 to 30% in 2050 due to the extension of the threshold for particle numbers from 23 nm to 10 nm. NH_3 emissions from cars and vans are expected to decrease by 7% in 2030 to 47% in 2050 due to the technology-neutral use of a NH_3 limit for all vehicle categories. CO emissions from cars and vans are expected to decrease to a lesser extent. These emissions are expected to decrease by 3% in 2030 and by 12% in 2050 following the introduction of a technology-neutral CO limit for cars and vans. It seems that to optimise performance and to protect emission control components against high exhaust temperatures, engines may be shifted to rich fuel operation when outside of the current RDE conditions. Such fuel-rich conditions are known to produce high CO emissions in the engine.[96]

For lorries and buses, NO_x emission savings are the only emission savings expected in policy option 1. No new emission limits are considered for these vehicles, as the Euro VI limits are already technology-neutral. The decreases in NO_x emissions, 7% in 2030 to 19% in 2050, derive from enhanced real-driving testing covering conditions outside the current PEMS boundaries and assumed increased frequency of ISC and MaS testing.[97]

[96] Supporting Euro 7 impact assessment study, chapter 5.1.1. Environmental impacts
[97] See footnote 96

Table 11 – Emission savings for regulated pollutants from road transport in policy option 1 compared to the baseline[98]

Pollutant		**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Cars and vans							
NO_x	in kt	17.79	87.9	104.10	80.60	44.56	15.80
	in %	1.72	13.40	26.73	39.04	49.11	55.17
$PM_{2.5}$, total	in kt	0.04	0.17	0.19	0.14	0.07	0.02
	in %	0.08	0.51	0.80	0.99	1.14	1.20
$PM_{2.5}$, exhaust	in kt	0.04	0.17	0.19	0.14	0.07	0.02
	in %	0.29	4.31	12.80	20.54	25.72	28.78
PN_{10}	in #	5.77E+22	2.69E+23	2.92E+23	2.04E+23	9.95E+22	3.22E+22
	in %	0.32	5.06	15.18	22.54	26.97	30.33
CO	in kt	5.64	28.30	34.06	26.36	13.86	4.72
	in %	0.37	2.94	5.83	8.49	10.79	12.35
THC	in kt	0.09	0.45	0.54	0.43	0.24	0.08
	in %	0.03	0.21	0.37	0.49	0.50	0.42
NMHC	in kt	0.04	0.19	0.22	0.16	0.08	0.03
	in %	0.02	0.11	0.18	0.22	0.20	0.15
NH_3	in kt	0.03	1.92	5.13	5.34	2.93	0.98
	in %	0.12	7.32	21.49	33.36	41.22	46.61
CH_4	in kt	0.05	0.25	0.33	0.27	0.16	0.06
	in %	0.13	0.74	1.21	1.58	1.87	2.07
N_2O	in kt	0.05	0.34	0.57	0.55	0.34	0.12
	in %	0.22	0.99	1.38	1.65	1.88	2.07
Lorries and buses							
NO_x	in kt	9.43	57.81	99.86	112.89	98.15	84.96
	in %	0.89	7.14	14.16	18.20	19.27	19.30
$PM_{2.5}$, total	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
$PM_{2.5}$, exhaust	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
PN	in #	0	0	0	0	0	0
	in %	0	0	0	0	0	0
CO	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
THC	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
NMHC	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
NH_3	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0
CH_4	in kt	0	0	0	0	0	0
	in %	0	0	0	0	0	0

1.2.3.2. Environmental impacts in policy option 2

The environmental impacts in terms of air pollutant emission reductions from road transport are the emission savings that would be achieved over the savings expected in the baseline with merely Euro 6/VI vehicle fleet renewal in combination with the impact

[98] See footnote 38

of the new CO_2 standards.

In policy option 2, stricter emission limits in medium and high ambition are considered for all vehicle categories and pollutants regulated under Euro 6/VI (NO_x, PM, PN, CO, THC, NMHC, NH_3, CH_4), new emission limits for the unregulated pollutants N_2O, HCHO and brake emissions[99] and extended real-driving testing. Sub-option 2a considers a Medium Green Ambition with medium ambition limits and real-driving testing boundaries (see Table 50); sub-option 2b considers a High Green Ambition with high ambition limits and real-driving testing boundaries (see Table 51).

Medium Green Ambition (option 2a)

As shown in Table 12, the emission savings that can be expected in sub-option 2a compared to the baseline are significant, in particular for lorries and buses. However, also the decrease of emissions for cars and vans is relevant, as those vehicles are predominantly used in densely populated urban areas where more citizens are exposed to respiratory health risk.

For cars and vans, NO_x emissions are expected to decrease significantly and rapidly compared to the baseline by 21% in 2030, 42% in 2035, 62% in 2040 to 88% in 2050. This significant decrease follows from the introduction of medium ambition extended real-driving testing covering more conditions outside the current RDE boundaries and a technology-neutral NO_x emission limit of 30 mg/km for cars, which replaces the current diverging NO_x limits in the Euro 6 standard of 60 mg/km for petrol cars and 80 mg/km for diesel cars. The decrease illustrates that cars and vans go more rapidly toward zero-pollution levels (about 80 kt NO_x/a) in 2040, compared to similar levels reached in 2050 in the baseline.

Significant savings can be expected also due to the more stringent air pollutant emission limits and increased durability requirements for particles, hydrocarbons, NH_3 and N_2O emissions from cars and vans. Regarding particles, $PM_{2,5}$ exhaust emissions are expected to decrease by 5% in 2030 to 22% in 2050 and PN emissions by 15% in 2030 to 88% in 2050 (PM exhaust and PN emissions also thorough inclusion of DPF regeneration control[100]). Brake emissions, which have become increasingly relevant sources of non-exhaust particles, are assumed to go down by 16% in 2030 to 36% in 2050 through the use of brake pads. CO emissions are expected to decrease by 14% in 2030 to 47% in 2050, NMHC by 13% in 2030 to 26% in 2050 and CH_4 emissions by 15% in 2030 to 32% in 2050. NH_3 emissions from cars and vans are presumed to drop by 11% in 2030 to 74% in 2050, and N_2O emissions by 7% in 2030 to 55% in 2050.

For lorries and buses, the highest emission savings can be expected under sub-option 2a due to the more stringent air pollutant emission limits for NO_x, particles, hydrocarbons, NH_3 and N_2O emissions. NO_x emissions are assumed to decrease by 209 kt in 2030 to 411 kt in 2050. This high reduction comes from the fact that in the EU fleet a significant number of heavy-duty vehicles, in particular diesel lorries, is still expected to be equipped with a combustion engine vehicle until 2050.

[99] As there are no testing methods for brake emissions from lorries and buses and for tyre emissions from all vehicle categories developed so far, the environmental impact of those non-exhaust particles cannot be determined and subsequently assessed.

[100] Supporting Euro 7 impact assessment study, chapter 5.2.1. Environmental impacts

$PM_{2,5}$ emissions are expected to decrease by 2.1 kt in 2030 to 3.1 kt in 2050, with a larger relative impact on PN emissions decrease due to the required particle filter for PI vehicles[101]. CO emissions are expected to fall by 6.4 kt in 2030 to 16 kt in 2050, also by control of emissions under the complete engine operation map, as CO emissions could increase somewhat for the vehicle to meet the required NO_x reductions at cold-start[102]. Moreover, THC emissions are presumed to drop by 2 kt in 2030 to 3.3 kt in 2050, NH_3 emissions by 2.0 kt in 2030 to 2.6 kt in 2050, and N_2O emissions by 25 kt in 2030 to 32 kt in 2050.

Table 12 – Emission savings for pollutants from road transport in policy option 2a compared to the baseline[103]

Pollutant		2025	2030	2035	2040	2045	2050
Cars and vans							
NO_x	in kt	27.97	138.31	165.00	128.60	71.33	25.31
	in %	2.71	21.07	42.37	62.28	78.61	88.37
$PM_{2.5,brake\ emissions}$	in kt	0.44	2.55	4.22	5.41	6.01	6.16
	in %	2.96	16.34	26.32	32.63	35.52	36.28
$PM_{2.5,exhaust}$	in kt	0.04	0.20	0.23	0.15	0.06	0.02
	in %	0.35	5.06	14.99	21.61	22.39	21.97
PN_{10}	in #	1.73E+23	8.00E+23	8.67E+23	6.03E+23	2.90E+23	9.29E+22
	in %	0.97	15.09	45.09	66.50	78.53	87.55
CO	in kt	28.20	137.96	169.67	124.68	58.28	18.09
	in %	1.86	14.31	29.03	40.16	45.36	47.36
THC	in kt	5.99	28.87	32.89	24.34	13.29	5.31
	in %	2.15	13.62	22.51	27.38	27.82	26.95
NMHC	in kt	5.16	23.75	25.46	18.71	10.54	4.45
	in %	2.13	13.34	21.36	26.13	26.83	26.16
NH_3	in kt	0.41	2.83	7.70	8.38	4.68	1.56
	in %	1.58	10.75	32.30	52.30	65.87	74.27
CH_4	in kt	0.82	5.12	7.43	5.64	2.74	0.87
	in %	2.23	15.09	27.66	32.57	32.42	31.86
N_2O	in kt	-0.42	2.39	12.35	15.20	9.15	3.31
	in %	-1.85	6.88	29.93	45.18	51.08	54.80
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Lorries and buses							
NO_x	in kt	32.44	209.13	389.30	480.90	455.90	410.60
	in %	3.06	25.83	55.19	77.55	89.48	93.30
$PM_{2.5,\ total}$	in kt	0.37	2.08	3.44	3.88	3.50	3.08
	in %	1.46	9.50	17.71	23.88	27.59	29.02
$PM_{2.5,exhaust}$	in kt	0.37	2.08	3.44	3.88	3.50	3.08
	in %	2.61	19.40	39.08	54.35	62.74	65.37
PN_{10}	in #	2.93E+22	1.94E+23	3.44E+23	4.30E+23	4.11E+23	3.70E+23
	in %	0.37	10.08	45.88	71.66	78.38	79.95
CO	in kt	0.69	6.42	13.58	18.42	17.66	15.95
	in %	0.32	4.70	12.18	17.42	18.97	19.17
THC	in kt	0.33	2.00	3.49	4.06	3.69	3.27
	in %	1.35	8.08	13.15	15.06	15.44	14.90
NMHC	in kt	0.36	2.13	3.70	4.30	3.92	3.47

101 See footnote 100
102 See footnote 100
103 See footnote 38

	in %	1.70	11.73	22.24	29.04	31.65	30.09
NH_3	in kt	0.37	2.04	3.19	3.41	2.98	2.58
	in %	4.80	22.52	33.14	37.24	38.79	38.99
CH_4	in kt	-0.02	-0.13	-0.21	-0.25	-0.23	-0.21
	in %	-0.63	-2.03	-2.14	-2.02	-2.01	-2.00
N_2O	in kt	4.61	25.13	39.45	42.28	37.08	32.17
	in %	4.68	23.97	40.35	51.72	58.16	60.06
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

High Green Ambition (option 2b)

As shown in Table 13, the emission savings that can be expected in sub-option 2b compared to the baseline are significant, in particular for lorries and buses. In comparison to sub-option 2a, stricter emission limits are assumed for NO_x emissions from cars and vans (20 mg/km instead of 30 mg/km) and lorries and buses (100 mg/kWh instead of 150 mg/kWh), and NMHC (20 mg/km instead of 40 mg/km) and brake emissions (5 instead of 7 mg/km) from cars and vans.

It is important that sub-option 2b is expected to lead only to marginal reductions of NO_x and NHMC emission compared to sub-option 2a.

For cars and vans, the marginal NO_x effect (-21.1% in 2030 and -88.4% in 2050 in sub-option 2a and -21.4% in 2030 and -90.4% in 2050 in sub-option 2b) is explained by the fact that manufacturers consider a safety factor to comply with emission limits, which results in average emissions being lower than the emission limit. Assuming a 30 mg/km emission limit for NO_x under sub-option 2a would already lead to a very low average emission level, which is not expected to be significantly lowered with a 20 mg/km emission limit under sub-option 2b. For lorries and buses, the marginal NO_x effect (-25.8% in 2030 and -93.3% in 2050 in sub-option 2a and -26.0% in 2030 and -93.8% in 2050 in sub-option 2b) is explained by the fact that the testing conditions are already comprehensively extended in sub-option 2a leading to the major positive effect on the emission performance, whereas the reduction of the NO_x limit from 150 mg/kWh to 100 mg/kWh and the extended real-driving testing boundaries in sub-option 2b offers a low emission savings.[104]

Reductions are expected for non-exhaust $PM_{2.5}$ emissions from cars and vans, since sub-option 2b includes more stringent limits for brake emissions which require brake pads and the installation of brake dust particle filter in the vehicle. That way, brake emission savings are achieved (54% in 2050 in sub-option 2b compared to 36% in 2050 in sub-option 2a).

Table 13 – Emission savings for pollutants from road transport in policy option 2b compared to the baseline[105]

Pollutant		2025	2030	2035	2040	2045	2050
Cars and vans							
NO_x	in kt	28.45	140.6	167.60	130.90	72.80	25.88
	in %	2.76	21.42	43.04	63.43	80.27	90.35

[104] See footnote 100
[105] See footnote 38

$PM_{2.5,brake}$ emissions	in kt	0.66	3.83	6.33	8.12	9.02	9.24
	in %	4.44	24.51	39.48	48.95	53.28	54.42
$PM_{2.5,}$ exhaust	in kt	0.05	0.23	0.25	0.19	0.10	0.03
	in %	0.39	5.69	16.90	27.16	34.08	38.19
PN_{10}	in #	1.74E+23	8.06E+23	8.73E+23	6.09E+23	2.94E+23	9.49E+22
	in %	0.97	15.20	45.42	67.22	79.85	89.38
CO	in kt	30.05	146.60	179.50	139.30	69.90	22.87
	in %	1.98	15.20	30.70	44.86	54.42	59.86
THC	in kt	6.50	31.29	35.61	27.67	15.79	6.51
	in %	2.33	14.76	24.38	31.13	33.06	33.00
NMHC	in kt	5.67	26.17	28.14	20.92	11.90	5.15
	in %	2.35	14.70	23.60	29.22	30.29	30.28
NH_3	in kt	0.41	2.83	7.71	8.46	4.81	1.63
	in %	1.59	10.78	32.34	52.80	67.69	77.26
CH_4	in kt	0.82	5.12	7.47	6.76	3.88	1.36
	in %	2.23	15.09	27.82	39.04	45.91	49.96
N_2O	in kt	0.49	6.81	17.46	20.50	13.12	4.92
	in %	2.16	19.59	42.31	60.93	73.28	81.48
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Lorries and buses							
NO_x	in kt	32.66	210.40	391.50	483.60	458.60	413.20
	in %	3.08	25.98	55.49	77.99	90.02	93.88
$PM_{2.5,}$ total	in kt	32.66	210.40	391.50	483.60	458.60	413.20
	in %	3.08	25.98	55.49	77.99	90.02	93.88
$PM_{2.5,}$ exhaust	in kt	0.37	2.09	3.46	3.93	3.57	3.17
	in %	2.61	19.44	39.31	55.14	64.16	67.17
PN_{10}	in #	2.94E+22	1.95E+23	3.44E+23	4.31E+23	4.12E+23	3.71E+23
	in %	0.37	10.08	45.91	71.76	78.54	80.15
CO	in kt	1.67	11.92	22.43	28.77	27.48	24.80
	in %	0.77	8.72	20.11	27.21	29.53	29.80
THC	in kt	0.36	2.13	3.71	4.33	3.96	3.52
	in %	1.44	8.62	13.97	16.07	16.59	16.06
NMHC	in kt	0.38	2.24	3.89	4.53	4.15	3.69
	in %	1.79	12.35	23.33	30.59	33.52	31.95
NH_3	in kt	0.37	2.04	3.21	3.49	3.11	2.72
	in %	4.80	22.52	33.31	38.12	40.41	41.12
CH_4	in kt	-0.02	-0.11	-0.18	-0.20	-0.19	-0.17
	in %	-0.53	-1.71	-1.80	-1.67	-1.63	-1.61
N_2O	in kt	4.61	25.13	39.68	43.43	38.88	34.21
	in %	4.68	23.97	40.59	53.13	60.98	63.86
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

1.2.3.3. Environmental impacts in policy option 3

The environmental impacts in terms of air pollutant emission reductions from road transport are the emission savings that would be achieved over the savings expected in the baseline with merely Euro 6/VI vehicle fleet renewal in combination with the impact of the new CO_2 standards.

Policy option 3a considers the introduction of continuous emission monitoring (CEM), to control real-driving emissions throughout the vehicle's lifetime in a Medium Green and

Digital Ambition. It is based on available NO_x, NH_3 and PM sensor technologies (see Table 55). Policy option 3a builds on the medium ambition stricter air pollutant emission limits, real-driving testing boundaries and durability requirements as policy option 2a (see Table 50).

As shown in Table 14, the emission savings that can be expected in PO3a compared to the baseline are significant, in particular for lorries and buses. Also for cars and vans very low NO_x emission levels are reached in 2040, compared to 2050 in the baseline.

Through the introduction of CEM for NO_x and NH_3 emissions, some savings are expected to be achieved compared to the introduction of strict emission limits (PO2a), by guaranteeing lifetime compliance with emission limits and improved protection against tampering with the NO_x emission control system. For cars and vans, NO_x emissions are expected to decrease by 141 kt in 2030, 132 kt in 2040 to 26 kt in 2050 (compared to 138 kt in 2030, 129 kt in 2040 to 25 in 2050 in policy option 2a). For lorries and buses, NO_x emissions are expected to decrease by 211 kt in 2030, 485 kt in 2040 to 415 kt in 2050 (compared to 209 kt in 2030, 481 kt in 2040 to 411 kt in 2050 in policy option 2a).

Some emission savings are also expected by the use of NH_3 sensors over the vehicle's lifetime. For cars and vans, NH_3 emissions are expected to decrease by 2.8 kt in 2030, 8.8 kt in 2040 to 1.7 kt in 2050 (compared to 2.8 kt in 2030, 8.4 kt in 2040 to 1.6 in 2050 in policy option 2a). For lorries and buses, NH_3 emissions are expected to decrease by 2.3 kt in 2030, 4.0 kt in 2040 to 3.1 kt in 2050 (compared to 2.0 kt in 2030, 3.4 kt in 2040 to 2.6 kt in 2050 in policy option 2a).

Table 14 – Emission savings for pollutants from road transport in policy option 3a compared to the baseline[106]

Pollutant		2025	2030	2035	2040	2045	2050
Cars and vans							
NO_x	in kt	28.59	141.30	168.60	131.90	73.50	26.20
	in %	2.77	21.53	43.31	63.90	81.03	91.33
$PM_{2.5,brake\ emissions}$	in kt	0.44	2.55	4.22	5.41	6.01	6.16
	in %	2.96	16.34	26.32	32.63	35.52	36.28
$PM_{2.5,exhaust}$	in kt	0.04	0.20	0.23	0.15	0.06	0.02
	in %	0.35	5.06	14.99	21.61	22.39	21.97
PN_{10}	in #	1.73E+23	8.00E+23	8.67E+23	6.03E+23	2.90E+23	9.29E+22
	in %	0.97	15.09	45.09	66.50	78.53	87.55
CO	in kt	28.20	138.00	169.70	124.70	58.30	18.10
	in %	1.86	14.31	29.03	40.16	45.36	47.36
THC	in kt	6.01	29.70	34.56	26.17	14.83	6.49
	in %	2.16	14.01	23.65	29.44	31.05	32.92
NMHC	in kt	5.19	24.58	27.13	20.53	12.09	5.62
	in %	2.15	13.80	22.75	28.68	30.75	33.09
NH_3	in kt	0.41	2.84	7.95	8.81	5.04	1.71
	in %	1.58	10.80	33.33	54.97	70.87	81.13
CH_4	in kt	0.82	5.12	7.43	5.64	2.74	0.87
	in %	2.23	15.09	27.66	32.57	32.42	31.86
N_2O	in kt	-0.42	2.39	12.35	15.20	9.15	3.31
	in %	-1.85	6.88	29.93	45.18	51.08	54.80
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[106] See footnote 38

	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Lorries and buses							
NO_x	in kt	32.78	211.20	392.80	485.30	460.20	414.70
	in %	3.10	26.08	55.69	78.25	90.34	94.22
$PM_{2.5,total}$	in kt	0.37	2.08	3.44	3.88	3.50	3.08
	in %	1.46	9.50	17.71	23.88	27.59	29.02
$PM_{2.5,}$ exhaust	in kt	0.37	2.08	3.44	3.88	3.50	3.08
	in %	2.61	19.40	39.08	54.35	62.74	65.37
PN_{10}	in #	2.94E+22	1.95E+23	3.44E+23	4.30E+23	4.11E+23	3.70E+23
	in %	0.37	10.08	45.88	71.66	78.38	79.95
CO	in kt	0.69	6.42	13.58	18.42	17.66	15.95
	in %	0.32	4.70	12.18	17.42	18.97	19.17
THC	in kt	0.33	2.00	3.49	4.06	3.69	3.27
	in %	1.35	8.08	13.15	15.06	15.44	14.90
NMHC	in kt	0.36	2.13	3.70	4.30	3.92	3.47
	in %	1.70	11.73	22.24	29.04	31.65	30.09
NH_3	in kt	0.42	2.31	3.64	3.96	3.52	3.08
	in %	5.44	25.50	37.72	43.17	45.76	46.56
CH_4	in kt	-0.02	-0.13	-0.21	-0.25	-0.23	-0.21
	in %	-0.63	-2.03	-2.14	-2.02	-2.01	-2.00
N_2O	in kt	4.61	25.13	39.45	42.28	37.08	32.17
	in %	4.68	23.97	40.35	51.72	58.16	60.06
HCHO	in kt	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	in %	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

1.3. Cost modelling, cost-benefit and cost-effectiveness analysis

1.3.1. Cost modelling

In order to perform the cost-benefit analysis, the total regulatory cost should be calculated next to the health and environmental benefits. In order to model these costs, the regulatory cost following the implementation of each policy option should be considered, compared to the baseline. Equation 4 shows that this cost is the difference in costs over the baseline without taxes and profit margins.

Equation 4[107]

$$\textit{Incremental Cost} = \Delta(\textit{Final Price} - \textit{Taxes} - \textit{Mark-up})$$

The total regulatory costs related to the introduction of Euro 6/VI for the evaluation and related to the introduction of Euro 7 for the impact assessment are calculated as the sum of the costs over multiple cost categories, comprising substantive compliance costs and administrative costs. Considering the costs over these different categories should enhance the accuracy of the total regulatory cost by minimising uncertainty. The considered cost categories are presented in Tavle 39 in Annex 5. In the context of the impact assessment, for each policy option one or more of these cost elements need to be assessed in order to find the total societal cost, expressed as monetised health and environmental benefits. For the evaluation of Euro 6/VI, these cost elements and the respective values are discussed in detail and per stakeholder group in the Efficiency chapter.

The cost data have been verified by stakeholders and the remaining uncertainty has been estimated for all vehicles in the cost-benefit analysis (see section 1.3.2.1).

[107] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.5 Cost modelling

Each cost element is calculated over a specific unit and then scaled up to the total. These units are summarized below:

- *Number of new vehicle registrations per vehicles category* – these are obtained through the SIBYL model
- *Number of engine/model families per vehicle category* – estimated based on data from IHS Markit Database[108]. It was assumed that the current average per year will not change significantly in the future.
- *Number of type-approvals* – based on data provided by a group of type-approval authorities, presenting around 67% of the total WVTA, and extrapolated to the total EU. On the basis of this number the total average number of TAA per year was estimated. For the evaluation, an increase in the number of type-approvals for the period 2018-2020 was observed, which was linked to the need for further type-approvals following the staged introduction of Euro 6. However, the number is expected to remain constant afterwards.
- *Number of vehicle manufacturers affected* – based on information on the number of vehicle sales per manufacturer as provided by ACEA. The cost estimates focused on the main manufacturers in the different vehicle categories that, put together, represent more than 90% of the total sales.
- *Number of calibrations* – based on data from IHS Markit Database[109] on number of engine families to develop an estimate of the number of calibrations taking place per manufacturer and per year.

In addition, the assumptions made for the cost assessment are summarized in Box 4.

Box 4 – Key assumptions for cost modelling[110]

- **Discount rate:** 4%
- **Learning effect for new hardware:** The hardware costs are expected to decrease over time as the state of the art evolves and manufacturers and suppliers become more familiar with the new technologies through a learning effect. The faster these effects play out, the lower the overall costs will be. In the analysis, it is assumed that new technology incremental costs drop to 50% within a six year time-frame after their first introduction.
- **Amortization period for R&D costs**: Since R&D costs are one-off incremental costs, the main R&D investment is practically materialised before the emission standard becomes available and is then amortized over a certain period that is assumed to be between 5-10 years[111]. In our approach we have assumed that R&D costs are linked to the first model families appearing at the year of introducing the new emission standard and are amortized over the lifetime of this first model, which is of the order of 8 years in the EU.
- **Learning effect for calibration costs**: Any additional calibration effort is consider to drop to 50% of the initial additional effort as the OEM becomes more experienced with calibrating the new technology, which is already expected with the second model series after the introduction of a new standard.
- **No learning effect for testing and witnessing costs:** Since costs are related to a procedure

[108] IHS Market, 2021. Provision of data on vehicle sales in the EU-28 for Evaluation of Euro 6/VI vehicle emission standards
[109] See footnote 108
[110] See footnote 107
[111] Rogozhin et al. 2010. Using indirect cost multipliers to estimate the total cost of adding new technology in the automobile industry.

demanded by the regulation, no significant cost reduction is expected over time.

The regulatory costs resulting from the cost modelling were used as input for assessing impacts in the areas of affordability for consumers and SME users. Assuming that a pass through of the costs takes place, consumers should be affected through an increase in vehicle prices. Assessing the relative impact can be examined by comparing vehicle prices with the costs per vehicle for Euro 6/VI or the different policy options to assess what share of a vehicle price they represent. Since vehicles in small size segments may not require all technologies identified in the default packages, prices and expected costs were compared for vehicles of similar size. To be more specific, low-end cost estimates were compared against the weighted average of vehicle prices[112] in the small size segments (mini/small), moderate cost estimates against the average price of the medium size segments vehicles (lower medium/medium/off-road/multi-purpose) and the high-end cost estimates against the higher cost segments of the large size segment vehicles (upper medium/sport/luxury).

While average prices from the ICCT were weighted against sales in 2018 and used for the assessment of affordability in the evaluation (see Table 41 Annex 5), in the impact assessment three additional steps were added. First, the ICE price projections of the Bloomberg New Energy Finance (BNEF) study[113] were used. That way, 1.5% annual price increases were assumed in the large vehicle segment, 2% in the medium vehicle segment and 2.5% in the small vehicle segment. Then, these increasing vehicle prices over the assessed period were discounted using the social discount rate of 4% and expressed in 2025 values. Finally, these results were weighted against the modelled vehicle registrations for each year. The results are presented in Table 17, Table 22 and Table 25 below.

1.3.1.1. Regulatory costs in policy option 1

The simplification measures introduced in policy option 1 intend to reduce complexity, remove inconsistencies and improve efficiency in the legislation. That way, the policy option was expected to result in some cost reductions, especially for costs during implementation phase and administrative costs, largely due to the streamlining of testing procedures. Table 15 presents the regulatory costs for policy option 1 over those related to the baseline.

[112] Based on the respective shares of sales by vehicle segment and average price (including tax). Data are provided by ICCT in the EU Pocketbook (ICCT, 2019).
[113] Bloomberg New Energy Finance (BNEF), 2021. Hitting the EV Inflection Point – Electric vehicle price parity and phasing out combustion vehicle sales in Europe

Table 15 – Regulatory costs for automotive industry in policy option 1 compared to the baseline, in 2025 values[114]

	Cars and vans		Lorries and buses	
	PI	CI	PI	CI
1) Equipment costs				
• **Hardware costs (emission control technologies)**				
Cost per vehicle (€)	33.26	104.10	0.00	0.00
Total cost (billion €)	1.31	4.70	0.00	0.00
• **R&D and related calibration costs including facilities and tooling costs**				
Cost per vehicle (€)	27.55	32.17	102.86	102.86
Total cost (billion €)	1.08	1.45	0.13	0.52
2) Costs during implementation phase				
• **Testing costs (granting type-approval, verification procedures)**				
Cost per model/engine family (thousand €)	-2 345.40	-9 385.64	-7 439.25	-3 121.19
Cost per vehicle (€)	-22.31	-21.55	-70.83	-32.90
Total cost (million €)	-878.49	-972.25	-87.34	-167.34
• **Witnessing costs (by type-approval authorities)**				
Cost per model/engine family (thousand €)	-156.66	-626.90	-263.47	-110.54
Cost per vehicle (€)	-1.49	-1.44	-2.51	-1.17
Total cost (million €)	-58.68	-64.94	-3.09	-5.93
• **Type-approval fees, except witnessing costs**				
Cost per type-approval (thousand €)	-1.83	-2.37	-0.52	-0.51
Cost per vehicle (€)	-0.34	-0.33	-0.52	-0.24
Total cost (million €)	-13.32	-14.74	-0.64	-1.23
3) Administrative costs (information provision)				
Cost per type-approval (thousand €)	-97.40	-126.32	-31.08	-30.35
Cost per vehicle (€)	-18.03	-17.42	-31.12	-14.46
Total cost (million €)	-710.18	-785.98	-38.38	-73.53
Total regulatory costs				
Total regulatory cost per vehicle (€)	18.64	95.53	-2.12	54.09
Total regulatory cost until 2050 (NPV in billion € - 2025 values)	0.73	4.31	0.00	0.28

The hardware costs represent recurrent costs arising from the need to install emission control technologies on vehicles to meet the actions of policy option 1. In terms of technology, no new hardware will be required to comply with technology-neutral emission limits. Reason for this being that for petrol cars and vans no new limits are proposed, while today's Euro 6d diesel cars and vans seem to be compliant with the NO_x limit of 60 mg/km limit[115]. This reasoning also applies to the decrease of particle size threshold from 23 to 10 nm in policy option 1. New hardware is, however, required for cars and vans to ensure that emissions are also controlled in low ambition extended real-driving testing outside the current RDE boundaries. This would mean including a larger three-way catalytic converter (TWC) and an improved gasoline particulate filter (GPF) for some of the PI cars and vans, which is estimated to increase the hardware costs by €33 per vehicle. CI cars and vans will need better thermal management and larger

[114] Supporting Euro 7 impact assessment study, chapter 5.1.2. Economic impacts
[115] Derived from 45 RDE compliant tests of Euro 6d diesel cars and vans by JRC, TNO and GreenNCAP.

components of exhaust aftertreatment components, which is estimated to increase the hardware costs by €104 per vehicle. Since neither the emission limits nor the PEMS testing conditions have changed for lorries and buses in comparison to the baseline, no hardware costs are expected.

Table 16 - Assumed control technology packages for policy option 1 and the respective hardware costs per vehicle for the average vehicle compared to the baseline, 2021 values[116]

Category	Petrol	Diesel	CNG/LPG
	Cars and vans		
MHEV	• 50% Mild hybrid, base TWC, base GPF • Cost per vehicle: €0	• 50% current technology • Cost per vehicle: €0	• 100% Mild hybrid, advanced calibration, larger TWC • Cost per vehicle: €78.8
	• 50% Mild hybrid, advanced calibration, larger TWC, improved GPF • Cost per vehicle: €108.8	• 50 % Mild hybrid, advanced heating calibration, larger EATS cost per vehicle: €201.7	
PHEV	• 100% Plugin hybrid, base TWC, base GPF • Cost per vehicle: €0	• 100% Plugin hybrid, advanced heating calibration, larger EATS • Cost per vehicle: €201.7	• 100% Plugin hybrid, advanced calibration, larger TWC • Cost per vehicle: €78.8
	Lorries and buses		
-	-	• 100% current technology • Cost per vehicle: €0	• 100% current technology • Cost per vehicle: €0

Next to the hardware costs for cars and vans, automotive industry is faced with R&D and calibration costs. In comparison to the baseline, these costs amount to approximately €28-€32 per vehicle for cars and vans. Although no hardware costs is needed for lorries and buses, R&D costs are required to introduce the improved OBD functionality (see Table 47) on the vehicles and to attain the PN limits with decreased threshold of 10 nm. Due to the much smaller production volumes for lorries and buses in comparison to cars and vans, the R&D cost per vehicle is with €103 per vehicle higher, while the total cost are closer in range for the different vehicle categories.

In contrast to the equipment cost, the costs during implementation phase – including testing and witnessing costs and type-approval fees – are projected to decrease significantly with the implementation of simplification measures (see Table 47). The testing costs for PI cars and vans, for example, are estimated to decrease by €2 345 thousand per model family (€22 per vehicle), while the witnessing costs for this category are estimated to decrease by €157 thousand per model family (-€1.49 per vehicle). For CI vehicles, the savings in testing costs per model family go further with €9 386 thousand. However, due to the larger number of vehicles in the average CI model family the cost per vehicle also decreases by €22. The savings in witnessing costs per vehicle are found to be lower for CI cars and vans, than for PI cars and vans. In addition, the simplification measures would achieve significant costs savings during implementation phase for lorries and buses, especially for PI vehicles. Following the implementation of the simplification measures, the fees per type-approval are estimated to decrease to a similar extent for all vehicle categories.

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116 See footnote 107

Another set of significant cost savings is expected in administrative costs (information provision). The simplification measures related to the legislative process and the testing procedures is translated into an extensive decrease in administrative burden for all vehicle categories. The administrative costs per type-approval are estimated to decrease most for CI cars and vans. For CI cars and vans for example, a cost saving of €126 thousand per type-approval (€17 per vehicle) is expected to be realised.

Table 17 – Regulatory costs of policy option 1 compared to the baseline in comparison to average purchase prices per vehicle segment, in 2025 values

	Vehicle segment	Regulatory cost per vehicle (in €)	Average vehicle price (in €)	Share of vehicle price (in %)
Cars and vans PI	Small	18.64	17 281.92	0.11
	Medium	18.64	31 293.75	0.06
	Large	18.64	65 099.78	0.03
Cars and vans CI	Small	95.53	17 144.19	0.56
	Medium	95.53	31 044.35	0.31
	Large	95.53	64 580.95	0.15
Lorries	Small	48.00	79 389.47	0.06
	Medium	48.00	100 713.53	0.05
	Large	48.00	151 183.30	0.03
Buses	Small	-4.92	152 198.85	0.00
	Medium	-4.92	185 653.41	0.00
	Large	-4.92	217 376.97	0.00

1.3.1.2. Regulatory costs in policy option 2

Policy options 2a and 2b consider two levels of ambition (medium and high) for introducing stricter pollutant emission limits to the Euro 6/VI emission limits to provide appropriate and up-to-date limits for all relevant air pollutants (see Table 50 and Table 51). In addition, option 2 develops extended real-driving testing boundaries in two ambition levels (medium and high) to improve control of real-world emissions and builds on the same simplification measures as option 1 to reduce complexity of the Euro 6/VI emission standards. Stricter air pollutant limits for vehicles and comprehensive real-driving testing result in regulatory costs for automotive industry, while the simplification measures lead to the similar cost savings as in option 1. Table 18 presents the regulatory costs for policy option 2a over those related to the baseline, while Table 19 represents those for policy option 2b.

Table 18 - Regulatory costs for tailpipe and evaporative emissions for automotive industry in policy option 2a (medium ambition stricter emission limits and real driving testing boundaries) compared to the baseline, in 2025 values[117]

	Cars and vans		Lorries and buses	
	PI	**CI**	**PI**	**CI**
1) Equipment costs				
• **Hardware costs (emission control technologies)**				
Cost per vehicle (€)	81.07	328.35	1 137.71	1 481.04
Total cost (billion €)	3.19	14.82	1.40	7.53
• **R&D and related calibration costs including facilities and tooling costs**				
Cost per vehicle (€)	103.52	111.74	1 245.48	1 248.22
Total cost (billion €)	4.08	5.04	1.54	6.35
2) Costs during implementation phase				
• **Testing costs (granting type-approval, verification procedures)**				
Cost per model/engine family (thousand €)	-2 228.49	-9 385.64	-7 439.25	-3 121.19
Cost per vehicle (€)	-21.20	-21.55	-70.83	-32.90
Total cost (million €)	-834.70	-972.25	-87.34	-167.34
• **Witnessing costs (by type-approval authorities)**				
Cost per model/engine family (thousand €)	-156.66	-626.90	-263.47	-110.54
Cost per vehicle (€)	-1.49	-1.44	-2.51	-1.17
Total cost (million €)	-58.68	-64.94	-3.09	-5.93
• **Type-approval fees, except witnessing costs**				
Cost per type-approval (thousand €)	-1.83	-2.37	-0.52	-0.51
Cost per vehicle (€)	-0.34	-0.33	-0.52	-0.24
Total cost (million €)	-13.32	-14.74	-0.64	-1.23
3) Administrative costs (information provision)				
Cost per type-approval (thousand €)	-97.40	-126.32	-31.08	-30.35
Cost per vehicle (€)	-18.03	-17.42	-31.12	-14.46
Total cost (million €)	-710.18	-785.98	-38.38	-73.53
Total regulatory costs				
Total regulatory cost per vehicle (€)	143.54	399.36	2 278.22	2 680.49
Total regulatory cost until 2050 (NPV in billion € - 2025 values)	5.65	18.02	2.81	13.63

Table 19 - Regulatory costs for tailpipe and evaporative emissions for automotive industry in policy option 2b (high ambition stricter emission limits and real driving testing boundaries) compared to the baseline, in 2025 values[118]

	Cars and vans		Lorries and buses	
	PI	**CI**	**PI**	**CI**
1) Equipment costs				
• **Hardware costs (emission control technologies)**				
Cost per vehicle (€)	252.74	387.24	2 003.76	3 074.05

[117] Supporting Euro 7 impact assessment study, chapter 5.2.2. Economic impacts
[118] See footnote 117

Total cost (billion €)	9.95	17.47	2.47	15.64
• **R&D and related calibration costs including facilities and tooling costs**				
Cost per vehicle (€)	115.21	116.26	1 249.73	1 255.19
Total cost (billion €)	4.54	5.25	1.54	6.38
2) Costs during implementation phase				
• **Testing costs (granting type-approval. verification procedures)**				
Cost per model/engine family (thousand €)	-2 228.49	-9 385.64	-7 439.25	-3 121.19
Cost per vehicle (€)	-21.20	-21.55	-70.83	-32.90
Total cost (million €)	-834.70	-972.25	-87.34	-167.34
• **Witnessing costs (by type-approval authorities)**				
Cost per model/engine family (thousand €)	-156.66	-626.90	-263.47	-110.54
Cost per vehicle (€)	-1.49	-1.44	-2.51	-1.17
Total cost (million €)	-58.68	-64.94	-3.09	-5.93
• **Type-approval fees. except witnessing costs**				
Cost per type-approval (thousand €)	-1.83	-2.37	-0.52	-0.51
Cost per vehicle (€)	-0.34	-0.33	-0.52	-0.24
Total cost (million €)	-13.32	-14.74	-0.64	-1.23
3) Administrative costs (information provision)				
Cost per type-approval (thousand €)	-97.40	-126.32	-31.08	-30.35
Cost per vehicle (€)	-18.03	-17.42	-31.12	-14.46
Total cost (million €)	-710.18	-785.98	-38.38	-73.53
Total regulatory costs				
Total regulatory cost per vehicle (€)	326.88	462.76	3 148.51	4 280.48
Total regulatory cost until 2050 (NPV in billion € - 2025 values)	12.87	20.88	3.88	21.77

The hardware costs represent recurrent costs arising from the need to install engine and emission control technologies for tailpipe and evaporative emissions on vehicles to meet the requirements of policy option 2. The cost estimates in Table 18 and Table 19 show that for all vehicle categories the hardware costs are considerably higher in policy option 2b than in policy option 2a and 1. This demonstrates that the further decrease in emission limits and the further extension of real-driving testing boundaries in policy option 2b requires further technology at a higher cost. In Table 21, the assumed technology packages to comply with the stricter emission limits in policy option 2 for are presented, together with the hardware costs of these packages compared to the baseline, i.e. costs for Euro 6d / VI E technologies. These hardware costs show that higher effort is needed to curb pollutant emissions from diesel vehicles and from larger vehicles, compared to gasoline vehicles. Comparing the hardware costs with the other cost categories in the tables above, it is clear that the rise in hardware costs is the most extensive for all vehicle categories.

The hardware costs in Table 18 and Table 19 do not include the costs of technologies required for introducing a brake emission limit, as costs for brake pads are different between ICE/MHEV and PHEV/BEV vehicles due to the different technologies and braking patterns used for these vehicles (see Table 20).

Table 20 –Regulatory costs for brake emissions in policy option 2 compared to the baseline, in 2025 values

	Cars and vans		Lorries and buses	
	ICE/MHEV	PHEV/BEV	ICE/MHEV	PHEV/BEV

Option 2a – Medium Green Ambition				
1) Equipment costs				
• **Hardware costs (emission control technologies for brakes)**				
Cost per vehicle (€)	23.06	12.78	-	-
Total cost (billion €)	1.95	4.65	-	-
	Cars and vans		**Lorries and buses**	
	ICE/MHEV	**PHEV/BEV**	**ICE/MHEV**	**PHEV/BEV**
Option 2b – High Green Ambition				
1) Equipment costs				
• **Hardware costs (emission control technologies for brakes)**				
Cost per vehicle (€)	100.28	60.07	-	-
Total cost (billion €)	8.47	21.62	-	-

Table 21 - Assumed control technology packages for policy option 2 and the respective hardware costs per vehicle for the average vehicle compared to the baseline, 2021 values[119]

a) Exhaust emissions

Policy option	Category	Petrol	Diesel	CNG/LPG
Cars and vans				
2a	MHEV	• 100% Mild hybrid, advanced calibration, larger TWC, improved GPF • Cost per car: €88.0 • Cost per van:€78.2	• 100% Mild hybrid, advanced heating calibration, larger EATS, EHC • Cost per car: €312.2 • Cost per van: €455.6	• 100% Mild hybrid, advanced calibration, larger TWC • Cost per car: €69.7 • Cost per van: €73.2
	PHEV	• 80% Plugin hybrid, base TWC, base GPF • Cost per vehicle: €0.0 • 20% Plugin hybrid, advanced calibration, larger TWC, improved GPF • Cost per car: €88.0 • Cost per van: €78.2	• 100% Plugin hybrid, advanced heating calibration, larger EATS, EHC, turbine bypass • Cost per car: €487.2 • Cost per van: €630.6	• 100% Plugin hybrid, advanced calibration, larger TWC • Cost per car: €69.7 • Cost per van: €73.2
2b	MHEV	• 80% Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC • Cost per car: €233.8 • Cost per van: €222.8	• 20% Mild hybrid, advanced heating calibration, larger EATS, EHC • Cost per car: €326.7 • Cost per van: €473.5	• 80% Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC • Cost per car: €290.2 • Cost per van: €298.5
		• 20% Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 10s preheating, secondary air injection, NH3 catalyst • Cost per car: €334.6 • Cost per van: €320.9	• 80% Mild hybrid, advanced heating calibration, larger EATS, EHC, preheating, secondary air injection • Cost per car: €404.7 • Cost per van: €551.5	• 20% Mild hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 10s preheating, secondary air injection, NH3 catalyst • Cost per car: €386.1 • Cost per van: €394.5
	PHEV	• 50% Plugin hybrid, advanced calibration, larger TWC,	• 100% Plugin hybrid, advanced	• 50% Plugin hybrid, advanced calibration,

[119] See footnote 107

		improved GPF • Cost per car: €108.8 • Cost per van: €97.8	heating calibration, larger EATS, EHC, turbine bypass • Cost per car: €501.7 • Cost per van: €648.5	larger TWC, improved GPF, 4kW EHC • Cost per car: €165.2 • Cost per van: €173.5
		• 30% Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC • Cost per car: €233.8 • Cost per van: €222.8		• 30% Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC • Cost per car: €290.2 • Cost per van: €298.5
		• 20% Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 60s preheating, secondary air injection, NH3 catalyst • Cost per car: €334.6 • Cost per van: €320.9		• 20% Plugin hybrid, advanced calibration, larger TWC, improved GPF, 4kW EHC, 60s preheating, secondary air injection, NH3 catalyst • Cost per car: €386.1 • Cost per van: €394.5
Lorries and buses				
2a		-	• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR) • Cost per vehicle: €1 863	• 50% Advanced heating calibration, close-coupled EATS, optimised particulate filter, EGR (w/ cold SCR) • Cost per vehicle: €1 863
			• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR), EHC • Cost per vehicle : €2 913	• 50% λ=1, advanced heating calibration, close-coupled EATS, optimised particulate filter • Cost per vehicle: €2 112.7
2b		-	• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR), burner, preheating • Cost per vehicle: €3 463	• 50% Advanced heating calibration, close-coupled EATS, optimised particulate filter, EGR (w/ cold SCR), EHC • Cost per vehicle: €2 913
			• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR), EHC, preheating • Cost per vehicle: €5 263	• 50% λ=1, advanced heating calibration, close-coupled EATS, optimised particulate filter, EHC • Cost per vehicle: €3 162.7

b) Evaporative emissions

Policy option	Emission control technology	Hardware cost (€/vehicle)
Evaporative emissions from PI vehicles		
2a	ORVR canister, anti spitback/vapour seal valve, and a high flow purge valve	16
2b	Higher capacity canister and low permeability fuel tank and hoses	40

c) **Non-exhaust emissions**

Policy option	Emission control technology	Hardware cost (€/vehicle)
Brake emissions from cars and vans		
2a	NAO brake pads – ICE and MHEV	37.5
	NAO brake pads – PHEV and BEV	22.5
2b	NAO brake pads – ICE and MHEV	37.5
	NAO brake pads – PHEV and BEV	22.5
	Brake dust particulate filter	160

In contrast to the findings for the hardware costs, the R&D and related calibration costs including facilities and tooling costs are not expected to differ much between the different ambition levels. In comparison to the baseline, these costs are estimated to increase by €115 for PI and €116 for CI cars and vans in PO2a and by €104 for PI and €112 for CI cars and vans in PO2b. The R&D and related calibration costs per vehicle for lorries and buses is significantly higher and estimated at €1 245-€1 248 per vehicle in PO2a and at €1 250-€1 255 in PO2b. This is related to the lower number of produced vehicles in these segments, in comparison to cars and vans.

Since policy option 2 includes the simplification measures introduced in policy option 1, the costs savings in the testing and witnessing costs, the type-approval fees and administrative costs are for the largest share estimated at the same levels as in option 1. No costs during implementation phase compared to Euro 6/VI are assumed for both stringency levels and comprehensive real-driving testing.

On the other hand, battery durability requirements would not add any costs because the level of durability is set to the level already achieved by the average batteries of today and the costs for the verification are already included in the other tests, i.e. no new test will be required.

Overall, policy option 2a (Medium Green Ambition) and policy option 2b (High Green Ambition) are expected to result in a positive impact on European competitiveness in the automotive sector. Nevertheless, the implementation of stricter emission limits is expected to increase regulatory cost for automotive industry, to a higher extend in policy option 2b than in option 2a (see Table 18 and Table 19). Since the regulatory costs in both sub-options are significantly below the regulatory costs that came with the introduction of Euro 6/VI and the proposed CO_2 emission standards, any negative effect on competitiveness through the price is expected to be limited. This is in line with the evaluation of Euro 6/VI which illustrated that costs do not necessarily have a negative impact on the competitiveness of the EU industry.

Table 22 – Regulatory costs of policy option 2 compared to the baseline in comparison to average purchase prices per vehicle segment, in 2025 values

	Vehicle segment	Regulatory cost per vehicle (in €)	Average vehicle price (in €)	Share of vehicle price (in %)
Option 2a - medium ambition stricter emission limits and real driving testing boundaries				
Cars and vans PI	Small	144.75	17 281.92	0.84
	Medium	159.66	31 293.75	0.51

	Large	174.58	65 099.78	0.27
Cars and vans CI	Small	361.32	17 144.19	2.11
	Medium	390.16	31 044.35	1.26
	Large	428.26	64 580.95	0.66
Lorries	Small	2 481.46	79 389.47	3.13
	Medium	2 617.10	100 713.53	2.60
	Large	2 796.34	151 183.30	1.85
Buses	Small	2 328.11	152 198.85	1.53
	Medium	2 453.26	185 653.41	1.32
	Large	2 618.62	217 376.97	1.20
Option 2b - high ambition stricter emission limits and real driving testing boundaries				
Cars and vans PI	Small	383.86	17 281.92	2.22
	Medium	402.39	31 293.75	1.29
	Large	420.91	65 099.78	0.65
Cars and vans CI	Small	483.43	17 144.19	2.82
	Medium	511.78	31 044.35	1.65
	Large	550.27	64 580.95	0.85
Lorries	Small	3 855.85	79 389.47	4.86
	Medium	4 082.62	100 713.53	4.05
	Large	4 390.38	151 183.30	2.90
Buses	Small	3 621.52	152 198.85	2.38
	Medium	3 832.92	185 653.41	2.06
	Large	4 119.83	217 376.97	1.90

1.3.1.3. Regulatory costs in policy option 3

Policy option 3a considers the introduction of continuous emission monitoring, to control real-driving emissions throughout the vehicle's lifetime and in all driving conditions. It is based on available sensor technologies (see Table 55). In addition, option 3 builds on the same simplification measures as option 1 to reduce complexity of the Euro 6/VI emission standards and on more stringent air pollutant emission limits as option 2a and comprehensive real-driving conditions to provide appropriate and up-to-date limits for all relevant air pollutants.

On-board monitoring result in regulatory costs, while the simplification measures lead to the same cost savings as in option 1 and the introduction of strict emission limits based on available emission control technology lead to the same costs as in option 2a. Table 23 presents the regulatory costs for policy option 3a over those related to the baseline.

Table 23 - Regulatory costs for tailpipe and evaporative emissions for automotive industry in policy option 3a compared to the baseline, in 2025 values[120]

	Cars and vans		Lorries and buses	
	PI	**CI**	**PI**	**CI**
1) Equipment costs				
• **Hardware costs (emission control and sensor technologies)**				
Cost per vehicle (€)	128.94	353.93	1 160.56	1 507.41
Total cost (billion €)	5.08	15.97	1.43	7.67
• **R&D and related calibration costs including facilities and tooling costs**				
Cost per vehicle (€)	78.68	104.90	1 334.22	1 332.10
Total cost (billion €)	3.10	4.73	1.65	6.78
2) Costs during implementation phase				
• **Testing costs (granting type-approval. verification procedures)**				
Cost per model / engine family (thousand €)	-3 328.13	-11 630.89	-11 305.62	-4 775.22
Cost per vehicle (€)	-31.66	-26.70	-107.64	-50.33
Total cost (million €)	-1 246.57	-1 204.83	-132.73	-256.03
• **Witnessing costs (by type-approval authorities)**				
Cost per model / engine family (thousand €)	-230.11	-776.87	-400.41	-169.12
Cost per vehicle (€)	-2.19	-1.78	-3.81	-1.78
Total cost (million €)	-86.19	-80.48	-4.70	-9.07
• **Type-approval fees. except witnessing costs**				
Cost per type-approval (thousand €)	-3.83	-4.19	-1.12	-1.10
Cost per vehicle (€)	-0.50	-0.40	-0.79	-0.37
Total cost (million €)	-19.56	-18.26	-0.97	-1.88
3) Administrative costs (information provision)				
Cost per type-approval (thousand €)	-204.42	-223.60	-67.35	-66.30
Cost per vehicle (€)	-26.49	-21.59	-47.30	-22.12
Total cost (million €)	-1 043.14	-974.00	-58.33	-112.50
Total regulatory costs				
Total regulatory cost per vehicle (€)	146.79	408.36	2 335.25	2 764.90
Total regulatory cost until 2050 (NPV in billion € - 2025 values)	5.78	18.43	2.88	14.06

The hardware costs represent recurrent costs arising from the need to install emission control technologies to comply with strict emission limits as assumed in policy option 2a (see Table 20) and new sensor technologies for CEM, on vehicles to meet the actions of policy option 3. For policy option 3a, hardware costs for available NO_x, and NH_3 and PM sensor technologies are considered. Moreover, costs for over-the-air (OTA) data transmission is included, allowing also the possibility of geo-fencing[121]. A higher cost for OTA data transmission is assumed for lorries and buses, due to the higher complexity of the data monitoring system of a HDV over a car.

[120] Supporting Euro 7 impact assessment study, chapter 5.3.2. Economic impacts
[121] Geo-fencing puts a vehicle automatically into zero-emission mode depending on its geolocation, in particular in urban areas.

The hardware costs for every vehicle category are estimated to be lower in policy option 3a than in policy option 2b which considers the most stringent set of emission limits. In other words, the costs for available emission and sensor control technologies are lower than for best available emission control technology.

In addition, policy option 3a assumes the same hardware costs for brake emissions from cars and vans as in policy option 2a (see Table 20). That means, policy option 3a €21 per ICE/MHEV vehicle and €12 per PHEC/BEV vehicle for brake pads.

Table 24 - Assumed control technology packages for policy option 3a and the respective hardware costs per vehicle for the average vehicle compared to the baseline, 2021 values[122]

a) Exhaust emissions

<table>
<tr><th>Policy option</th><th>Category</th><th>Petrol</th><th>Diesel</th><th>CNG/LPG</th></tr>
<tr><td colspan="5">Cars and vans</td></tr>
<tr><td rowspan="3">3a</td><td rowspan="1">MHEV</td><td>• 100% Mild hybrid, advanced calibration, larger TWC, improved GPF
• Cost per car: €88.0
• Cost per van:€78.2</td><td>• 100% Mild hybrid, advanced heating calibration, larger EATS, EHC
• Cost per car: €312.2
• Cost per van: €455.6</td><td>• 100% Mild hybrid, advanced calibration, larger TWC
• Cost per car: €69.7
• Cost per van: €73.2</td></tr>
<tr><td rowspan="2">PHEV</td><td>• 80% Plugin hybrid, base TWC, base GPF
• Cost per vehicle: €0,0</td><td rowspan="2">• 100% Plugin hybrid, advanced heating calibration, larger EATS, EHC, turbine bypass
• Cost per car: €487.2
• Cost per van: €630.6</td><td rowspan="2">• 100% Plugin hybrid, advanced calibration, larger TWC
• Cost per car: €69.7
• Cost per van: €73.2</td></tr>
<tr><td>• 20% Plugin hybrid, advanced calibration, larger TWC, improved GPF
• Cost per car: €88.0
• Cost per van: €78.2</td></tr>
<tr><td colspan="5">Lorries and buses</td></tr>
<tr><td rowspan="2">3a</td><td rowspan="2"></td><td rowspan="2">-</td><td>• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR)
• Cost per vehicle: €1 863</td><td>• 50% Advanced heating calibration, close-coupled EATS, optimised particulate filter, EGR (w/ cold SCR)
• Cost per vehicle: €1 863</td></tr>
<tr><td>• 50% Advanced heating calibration, close-coupled EATS, twin urea dosing, optimised DPF, EGR (w/ cold SCR), EHC
• Cost per vehicle : €2 913</td><td>• 50% λ=1, advanced heating calibration, close-coupled EATS, optimised particulate filter
• Cost per vehicle: €2 112.7</td></tr>
</table>

b) Evaporative emissions

Policy option	Emission control technology	Hardware cost (€/vehicle)
Evaporative emissions from PI vehicles		

[122] See footnote 107

3a	ORVR canister, anti spitback/vapour seal valve, and a high flow purge valve, pump system for active leak detection (OBD)	41

c) Non-exhaust emissions

Policy option	Emission control technology	Hardware cost (€/vehicle)
Brake emissions from cars and vans		
3a	NAO brake pads – ICE and MHEV	37.5
	NAO brake pads – PHEV and BEV	22.5

For lorries and buses, the R&D and the related calibration costs are in general expected to be higher in policy option 3 than in the previous options. This follows from the fact that policy option 3 is the most advanced option including the previous options and hence bundling the R&D costs. For example, the R&D cost for CI lorries and buses is estimated at €1 051 per vehicle in 3a, in comparison with €992 per vehicle in policy option 2.

A different observation is made for the costs for PI cars and vans, for which the R&D and related calibration cost were estimated in policy option 2 with €80 per vehicle (due to the new emission technology introduced for PI vehicles) in comparison to €49 in policy option 3a. In case of CI cars and vans, the R&D costs and related calibration costs for policy option 3a are expected to be lower than the costs in option 2. The reason for this observation is that policy option 3 allows for some cost reductions through a decreased need for calibration following the introduction of continuous emission monitoring which makes it no longer necessary to infer emissions for the operation conditions.

In comparison to the estimates for option 2, the cost savings during implementation phase in option 3 go further for all three subcategories. This follows from the fact that the introduction of CEM facilitates the granting of type-approval and verification testing procedures (see Table 55), in addition to the simplification measures introduced in option 1 (see Table 47). The testing costs for PI cars and vans are estimated to decrease by €28 per vehicle in policy option 3a, compared to €19 per vehicle in policy option 2. Similar cost savings over policy option 2 are realised for the other vehicle and costs subcategories during implementation phase. The benefits from simplification of the type-approval procedure come from the fact that a drop of 30% in the number of necessary type-approvals is anticipated for policy option 3a. This drop is considered to reflect the fact that CEM can enable a wider family concept than the current model or engine family. By verifying a single OBM family, the type-approval authority would not need to verify all details of the emission control system but ensure that the OBM system measures and reports correctly.

The cost estimates for the administrative costs follow the same trend as the costs during implementation phase. The new CEM requirements in policy option 3 are expected to further simplify the reporting and other information provision obligations for granting type-approval and verification procedures which leads to cost savings for all vehicle categories compared to the other policy options.

Table 25 – Regulatory costs of policy option 3a compared to the baseline in comparison to average purchase prices per vehicle segment, in 2025 values

	Vehicle segment	Regulatory cost per vehicle (in €)	Average vehicle price (in €)	Share of vehicle price (in %)
Cars and vans PI	Small	139.20	17 281.92	0.81
	Medium	162.92	31 293.75	0.52
	Large	186.64	65 099.78	0.29
Cars and vans CI	Small	367.80	17 144.19	2.15
	Medium	399.06	31 044.35	1.29
	Large	440.38	64 580.95	0.68
Lorries	Small	2 560.56	79 389.47	3.23
	Medium	2 698.66	100 713.53	2.68
	Large	2 881.14	151 183.30	1.91
Buses	Small	2 380.35	152 198.85	1.56
	Medium	2 507.82	185 653.41	1.35
	Large	2 676.26	217 376.97	1.23

1.3.2. Cost-benefit analysis

For both the evaluation and the impact assessment, a cost-benefit analysis model was developed to examine the specific regulatory requirements of the current Euro 6/VI emission standards or the different policy options for a Euro 7 initiative. The aim of this analysis is to indicate whether the societal benefits achieved following the past and future initiatives at least even out the respective societal costs. Societal benefits comprise health and environmental benefits for citizens and regulatory costs savings (cost savings during implementation phase and administrative cost savings) for industry which are assumed to be passed on to citizens, whereas societal costs comprise regulatory costs (equipment costs) for industry which are also assumed to be passed on to citizens.

The introduction of new vehicle technologies following new policy requirements are modelled with SIBYL/COPERT[31,38] that calculate first the vehicle stock, activity and energy consumption. Subsequently, these new requirements should have a positive environmental and health impact through the reduction of total emission levels and regulatory cost savings through the simplification measures. On the other side, they could have a negative impact through increasing the regulatory costs. To compare the costs and benefits, the equivalent monetised health and environmental benefits are calculated by multiplying the emission savings in kg with the external marginal cost in €/kg for every investigated pollutant. The costs and benefits are then scaled up to represent the total regulatory costs and the total health and environmental benefit and total regulatory cost savings. Finally, the subtraction of the total costs from the total benefit results in the net benefit. If this number has a positive value, it means that a net benefit is achieved by the intervention, while a negative value means that a net damage is realised.

The net-present value (NPV) is derived by allocating the cost and benefit to the period of investigation based on a social discount rate. Following the recommendations from the Better Regulation Guidelines[123], a social discount rate of 4% has been applied in the analysis. To take into account the full range of the equivalent monetised benefits, a time horizon up to 2050 was considered. The considered discount rate results in any benefits reaching zero in approximately 30 years after the introduction of the new emission

[123] European Commission, 2020. Better Regulation Toolbox, Tool #61. The use of discount rates

requirements for vehicles. If a higher social discount rate and shorter simulation horizon was considered, many monetary benefits would have been neglected.

1.3.2.1. Uncertainty

Uncertainty in the cost-benefit analysis was reported for the cost modelling and was due to the limited cost data received from stakeholders during the public and target stakeholder consultations and the related follow-up on both Euro 6/VI evaluation and Euro 7 impact assessment. Due to lessons learnt from the Euro 6/VI evaluation (see Annex 5, section 4.2), the data collection, including confidential sharing of data by stakeholders, and validation by key stakeholders of regulatory costs and health and environmental benefits had a great importance in the impact assessment. The results and underlying assumptions have been cross-checked with independent experts and the concerned stakeholders.

The CLOVE consortium, in which key experts from a group of seven independent research organisations and universities join forces, carried out the studies supporting this impact assessment. While the Laboratory of Applied Thermodynamics of the Aristotle University of Thessaloniki (LAT) took the lead on the supporting impact assessment study, the work was subject to cross-checking between the different institutes. Next to that, everything has been discussed and verified by experts from the JRC in Ispra working on sustainable transport. In addition, concerned stakeholders were encouraged to verify or contest any result or assumptions in the extensive stakeholder consultation. During the ten official meetings of the Advisory Group on Vehicle Emission Standards (AGVES), stakeholders (mostly from automotive industry, Member States and NGOs) were brought up-to-date regularly on the ongoing work and were able to react on the spot, in written after a meeting or in the next meeting. Feedback received through this channel was carefully analysed by experts and taken into account if credible. For further details please see Annex 1 and 2.

All relevant stakeholder groups and JRC experts were requested to validate the CLOVE cost estimates[124]. In addition, relevant datasets from other sources were used to cross-check the estimates fleet or cost estimates, including the EEA NECD database[6], OECD statistics[125], the handbook on external costs and emission factors of Road Transport[126] and data on structural business statistics from Eurostat[127]; additional data on emission type-approvals from ten type-approval authorities[128] and on Euro 6/VI vehicle sales in the EU-28 from IHS Markit[129]. Additionally, CLOVE calculated multiple scenarios for critical assumptions, such as comparing emission limits for traditional tailpipe and evaporative emissions versus new brake emissions or normal versus conservative emission factor approach[130].

Following the validation, remaining uncertainty has been addressed and minimised by

[124] Supporting Euro 7 impact assessment study, Table 9-41: Sources and assumptions made per cost category
[125] OECD, 2020. Statistics on Patents –Technology Development Environment
[126] European Commission, 2019. Handbook on the external costs of transport
[127] Eurostat, 2020. Annual detailed enterprise statistics for industry (NACE Rev. 2, B-E) [sbs_na_ind_r2]
[128] Type-approval authorities provided emission type-approval data at the request of the European Commission
[129] IHS Markit, 2021. Provision of data on vehicle sales in the EU-28 for Evaluation of Euro 6/VI vehicle emission standards
[130] Supporting Euro 7 impact assessment study, chapter 6 Comparison of Policy Options

assessing the level of confidence for each regulatory cost category and the health and environmental benefit used in the cost-benefit analysis based on the availability and quality of information, data and the shared input by stakeholders. The assumed uncertainty for a high confidence level is at 10%, for a medium-high confidence level 15% and medium confidence level 20% (see Table 26).

While the level of confidence is considered high for costs during implementation phase and administrative costs, as the costs for testing, witnessing and type-approval is well known based on granting type-approval and verification procedures by type-approval authorities, the level of confidence for equipment costs is assessed medium to high. For R&D costs the upper estimates were based on the responses provided by manufacturers to the targeted consultations, and the hardware costs for Euro 7 emission control technologies is well known by CLOVE and JRC experts. The level of confidence for health and environmental benefits is assessed medium to high, as calculations are based on best available information on emission savings, including emission factors adjusted to the policy options by CLOVE and factors to monetise external costs. The concept of emission factors and external costs was developed by a consortium led by CE Delft for the Commission's Handbook on the external costs of transport[126] and is used by EU and national air quality and climate policies for road transport.

Table 26 – Estimated uncertainty for all vehicles in the cost-benefit analysis

Cost category	Level of confidence	Estimated uncertainty[1]
Regulatory costs		
1) Equipment costs		
Hardware costs (emission control technologies)	Medium/high	15%
R&D and related calibration costs including facilities and tooling costs	Medium	20%
2) Costs during implementation phase		
Testing costs (granting type-approval, verification procedures)	High	10%
Witnessing costs (by type-approval authorities)	High	10%
Type-approval fees, except witnessing costs	High	10%
3) Administrative costs		
Administrative costs (information provision)	High	10%
Health and environmental benefits	**Medium/high**	**15%**

In conclusion, the underlying methodology for the cost-benefit analysis is very robust due to the extensive stakeholder consultation process, the long-standing reputation of the SIBYL/COPERT models used by the Commission and EEA for pollutant modelling in EU air quality policies and the medium to high level of confidence level of the quantitative cost and benefit estimates. The cost-benefit analysis in Table 27 to Table 29 is complemented by providing ranges of expected costs and benefits to make political choices based on the net benefits and benefit-cost ratios of the policy options for light- and heavy-duty vehicles.

1.3.2.2. Efficiency of policy option 1-3

In order to assess efficiency of policy options, regulatory costs are compared with the health and environmental benefit of a reduction of air pollution and regulatory cost savings by simplification measures. The health and environmental benefit can be monetised using the concept of external costs, which reflect the damage costs by air pollution to environment and health, in particular medical treatment costs, production losses due to illnesses and even deaths. Decreasing pollution leads to a decrease of damage hence to an overall benefit. The results of this assessment (as net benefits i.e. the difference between the present value of the benefits and costs and as benefit-cost ratio (BCR)) is presented for tailpipe and evaporative emissions in Table 27. For methodological reasons and for clarity purposes, **the focus of the efficiency assessment is on net benefits** which are an indicator of the attractiveness of an option in absolute terms (thus the larger the difference between benefits and costs, the better) and do not bias the results for low-cost options, compared to the BCR.

The BCR gets disproportionally high when costs are low (see PO1 in Table 27 and Table 29) which gives an unjustified advantage to low-cost options and has the potential to mislead policy makers. Moreover, the BCR is independent form the scale of options considered, which contradicts the necessity to consider in absolute terms the regulatory costs and environmental and health benefits of reducing air pollutants. The BCR is therefore disregarded to choose one option and is included in the efficiency tables of the Annexes for completeness purposes only.

Table 27 – Assessment of efficiency of policy options for tailpipe and evaporative emissions compared to baseline*, 2025-2050, Introduction of Euro 7 in 2025, Data source: SIBYL/COPERT 2021

Policy option	**1 – Low Green Ambition**	**2a – Medium Green Ambition**	**2b – High Green Ambition**	**3a – 2a and Medium Digital Ambition**
Cars and vans				
Net benefits 2025 NPV (billion €)	17.33±2.23	21.25±2.55	16.58±1.82	21.64±2.61
Net benefits 2025 NPV (€/ vehicle)	205.03±27.19	251.38±30.27	196.15±21.58	256.11±31.02
Benefit-cost-ratio**	3.0 (2.2-4.1)	1.8 (1.3-2.5)	1.4 (1.1-1.9)	1.7 (1.3-2.4)
Lorries and buses				
Net benefits 2025 NPV (billion €)	20.86±3.08	116.10±17.00	108.36±15.84	116.64±17.03
Net benefits 2025 NPV (€/vehicle)	3 301.84±487.15	18 371.33 ±2 690.29	17 145.63 ±2 506.19	18 440.82 ±2 694.87
Benefit-cost-ratio**	33.1 (23.5-47.5)	7.9 (5.7-11.0)	5.2 (3.8-7.1)	7.7 (5.5-10.7)

** The baseline considers an end-date of combustion-engine cars/vans in 2035, see chapter 5.1.*
*** The benefit-cost ratio gets disproportionally high when costs are low which gives an unjustified advantage to low-cost options (i.e. PO1) and has the potential to mislead policy makers. The benefit-cost ratio is disregarded to choose one option based on benefits and costs in absolute terms only and included in this table for completeness purposes only.*

In addition to tailpipe and evaporative emissions, policy options 2 and 3 introduce limits for brake emissions from new vehicles. Brake wear has been recognized as the leading source of non-exhaust particles which are harmful to human health and emitted by all types of vehicles. Progress has been made in developing a measurement method in the GRPE Particle Measurement Programme for cars and vans[131], while the technologies to decrease brake emissions are already in the market or close to becoming commercial. While the brake emission limit of 7 mg/km in policy option 2a and 3a can be realised using better brake pad material, the stricter limit of 5 mg/km in policy option 2b and 3b require also a brake filter for the collection of the brake wear particles produced. As shown in Table 28 the use of brake filters is not cost-efficient (negative net benefits as

131 https://wiki.unece.org/display/trans/PMP+Workshop+on+Brake+Emissions++Regulation

costs are higher than benefits), resulting in significant decrease of the net benefits of policy option 2b and 3b for total emissions of vehicles (tailpipe, evaporative and brake emissions), as shown in Table 29. This may change in the future, once the brake filters become a more mature technology, and are also be applied for heavy-duty.

Table 28 – Assessment of efficiency of policy options for brake emissions of vehicles compared to baseline*, 2025-2050, Introduction of Euro 7 in 2025, Data source: SIBYL/COPERT 2021

Policy option	1 – Low Green Ambition	2a – Medium Green Ambition	2b – High Green Ambition	3a – 2a and Medium Digital Ambition
Brake emission limit	**-**	**7 mg/km**	**5 mg/km**	**7 mg/km**
Cars and vans				
Net benefits 2025 NPV (billion €)	-	3.30±0.50	-15.24±2.29	3.30±0.50
Net benefits 2025 NPV (€/ vehicle)	-	8.34±1.25	-38.48±5.77	8.34±1.25
Benefit-cost ratio	-	1.5 (1.1-2.0)	0.5 (0.4-0.7)	1.5 (1.1-2.0)

** The baseline considers an end-date of combustion-engine cars/vans in 2035, see chapter 5.1.*

Table 29 – Assessment of efficiency of policy options for total emissions of vehicles (tailpipe, evaporative, brake) compared to baseline*, 2025-2050, Introduction of Euro 7 in 2025, Data source: SIBYL/COPERT 2021

Policy option	1 – Low Green Ambition	2a – Medium Green Ambition	2b – High Green Ambition	3a – 2a and Medium Digital Ambition
Cars and vans				
Net benefits 2025 NPV (billion €)	17.33±2.23	24.55±3.05	1.34±0.47	24.94±3.11
Net benefits 2025 NPV (€/ vehicle)	205.03±27.19	259.72±31.52	157.67±15.81	264.45±32.27
Benefit-cost ratio**	3.0 (2.2-4.1)	1.7 (1.3-2.4)	1.0 (0.8-1.4)	1.7 (1.3-2.3)
Lorries and buses				
Net benefits 2025 NPV (billion €)	20.86±3.08	116.10±17.00	108.36±15.84	116.64±17.03
Net benefits 2025 NPV (€/vehicle)	3 301.84±487.15	18 371.33 ±2 690.29	17 145.63 ±2 506.19	18 440.82 ±2 694.87
Benefit-cost ratio**	33.1 (23.5-47.5)	7.9 (5.7-11.0)	5.2 (3.8-7.1)	7.7 (5.5-10.7)

** The baseline considers an end-date of combustion-engine cars/vans in 2035, see chapter 5.1.*
*** The benefit-cost ratio gets disproportionally high when costs are low which gives an unjustified advantage to low-cost options (i.e. PO1) and has the potential to mislead policy makers. The benefit-cost ratio is disregarded to choose one option based on benefits and costs in absolute terms only and included in this table for completeness purposes only.*

1.4. Methods for other direct and indirect economic and social impacts

Next to environmental benefits and economic costs discussed above, other direct and indirect impacts should be considered. This is especially relevant for economic and social impacts. Hence, this section focusses on the assessment of:

- General macro-economic indicators, such as creation of new jobs, skills required, research and innovation, etc.;
- Competitiveness of the EU industry and internal market cohesion;

- Qualitative impacts on SMEs and consumers (incl. consumer trust).

Key information, data and findings from the different tasks in the supporting Part A and Part B studies by CLOVE was used as the basis for the assessment of these socio-economic impacts of the Euro 6/V emission standards and the different policy options in Euro 7. Next to that, findings from relevant impact assessments or evaluations on similar topics (i.e. air quality and road transport) provided key insights and evidence on how past regulatory proposals and initiatives were projected to impact the social and economic dimensions allowing for direct comparisons and assumption in the context of Euro 6/VI and Euro 7. In parallel, an extensive literature review was conducted to find relevant scientific and consultant studies which focus on assessing the impact of new developments regarding technology, regulations, global markets, EU environmental policy, and how they affect the key elements identified above.

An important source of information for evaluating the socio-economic impacts in both the impact assessment and evaluation were the views of the different stakeholder groups collected through the extensive stakeholder consultation. While input from manufacturers and suppliers in the automotive industry were mostly crucial for assessing the impact on competitiveness, SMEs, employment and skills, the views from civil society were essential for assessing consumer trust and affordability for consumers.

In the impact assessment on Euro 7, matrices were created in order to compare quantifiable impacts on a custom scale for the different policy options and identify the most important topic areas. The scaling format in the assessment matrices includes both negative and positive values, as the nature of the impacts – being positive or negative – might be different for the different policy options and impacts. The quantifiable impacts and the scores are summarized in Table 30. All impacts are expressed on a relative scale to compare the different policy options to each other, with '+++' assumed to correspond to the maximum positive impact that any policy option can offer and "---" corresponding to the maximum negative impact.

Table 30 – Scores for economic, environmental and social impacts [132]

Impact	Score	Interpretation
High negative impact	---	High negative impact is considered when a negative impact is expected that could fundamentally change the concerned criterion.
Moderate negative impact	--	Moderate negative impact is considered when a negative effect that can clearly be felt is expected, but is not to an extent that can completely change the criterion concerned.
Low negative impact	-	Low negative impact is considered when a visible negative impact on the criterion is expected but not to an extent that would significantly change the area.
No impact	0	No impact is considered when no real differences are expected in the concerned criterion.
Low positive impact	+	Low positive impact is considered when a visible positive impact on the criterion is expected but not to an extent that would significantly change the area.
Moderate positive impacts	++	Moderate positive impact is considered when a positive effect that can clearly be felt is expected, but is not to an extent that can completely change the criterion concerned.
High positive impacts	+++	High positive impact is considered when a positive impact is expected

[132] Supporting Euro 7 impact assessment study, Annex 1: Analytical methods, 9.7 Other direct and indirect economic, environmental and social impacts

		that could fundamentally change the concerned criterion.

1.4.1. *Competitiveness: Export of EU motor vehicles to key destinations*

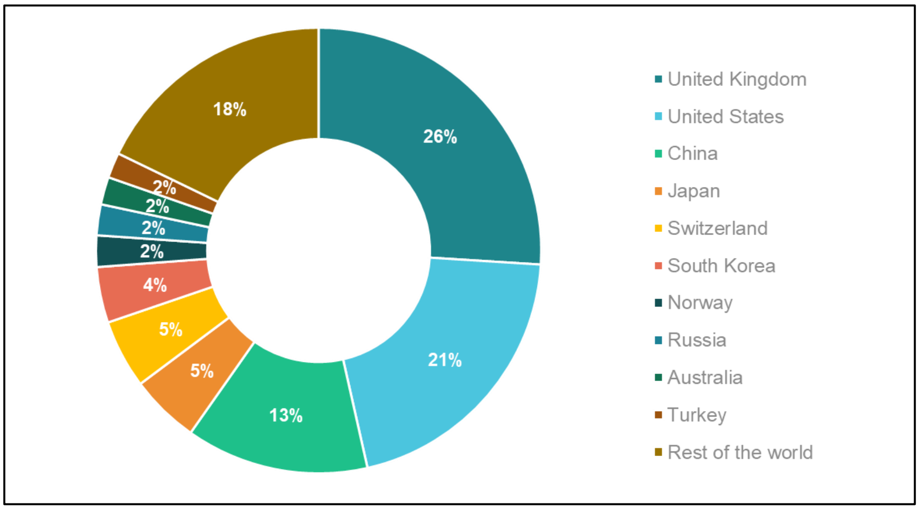
For the assessment of the impacts on competitiveness, the EU export of vehicles and the key destinations are further analysed in this section.

Table 31 illustrates how the car segment is the most crucial part of the EU-27 exports and trade surplus in the automobile trade. In 2019, €140.3 billion out of the €156.5 billion (i.e. 90%) earned by EU vehicle manufacturers in third countries was actually generated in this segment. Figure 12 illustrates that the United Kingdom, the United States and China represent the two biggest export markets for the EU automotive industry with 1.3, 0.8 and 0.4 million cars exported to the UK, the US and China respectively, resulting in exported in 2019 to the US and China respectively, resulting in €84 billion.[133] Next to China, East Asian countries Japan and South-Korea made up for a smaller 5 and 4 percent of the EU-27 export in cars in 2019. Also Norway, Switzerland and Turkey are important destinations for EU car exports.

Table 31 – EU-27 motor vehicle trade by vehicle type in 2019 (in billion €)[134]

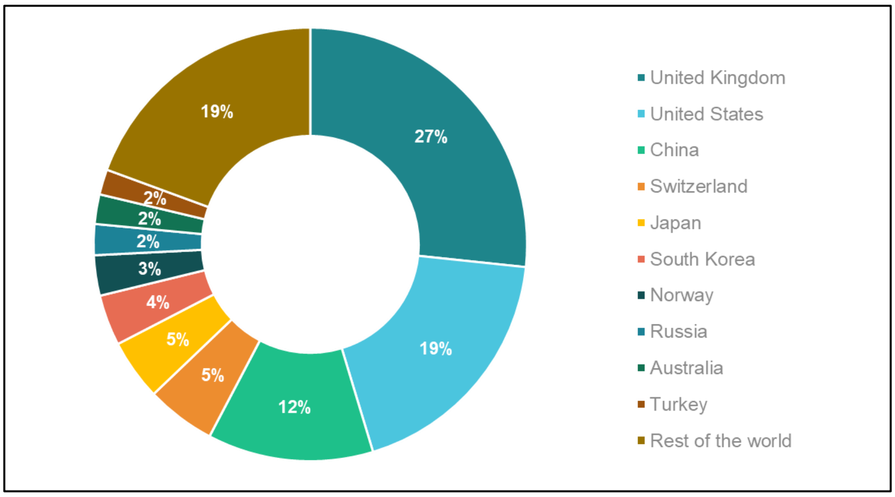
	Cars	Vans	Lorries and buses	Total
EU exports	140.3	7.6	8.6	156.5
Trade balance	71.2	2.2	5.8	85.2

Figure 12 – EU-27 passenger car exports, top 10 destinations (by value) in 2019 (total = €140.3 billion[135])



[133] ACEA, 2021. EU passenger car exports, top 10 destinations (by value)
[134] ACEA, 2020. EU motor vehicle trade, by vehicle type
[135] See footnote 133

Figure 13 – EU-27 motor vehicle (i.e. cars, vans, lorries and buses) exports, top 10 destinations (by value) in 2019 (total = €156.5 billion) [136]



Comparing the key destinations for EU cars exports to the key destinations of EU motor vehicles which also takes into account the values of the exports of vans, lorries and buses, only minimal differences are found (Figure 13). This is largely explained by the important share of cars in the trade numbers for the EU. Still, the share of exports to the US and China decreases somewhat, while exports to the UK, Norway and the rest of the world increases when looking into trade of all vehicle segments. Taking into account that the rest category also includes other EFTA countries and Eastern Europe, exports appear to be slightly more focussed on closer markets when also considering the larger vehicle segments.

Through further analysis of the 'rest of the world' category, it is found that in 2019 the EU-27 and the United Kingdom exported close to 7% of motor vehicles to the African continent.[137] However, this percentage is mainly due to the export of new EU motor vehicles to South-Africa (1.5%) and countries in North Africa, e.g. Morocco (1.1%), Egypt (0.9%), Algeria (0.7%) and Tunisia (0.4%). For the other African countries, the export of used vehicles is relatively more important. A report of the United Nations Environment Programme[138] found that in 2018 alone, the EU exported over 1 million used cars and vans to African countries, while more than 60% of vehicles added to their fleet annually is through the imports of used vehicles.[139]

In addition, several of the manufacturers of lorries and buses operating in the EU have also had a strong presence in the US market, in particular Daimler, PACCAR and Volvo.[140] However, in the Chinese and Asia Pacific markets this is less the case. These markets are dominated mainly by domestic manufacturers[141], although some EU companies such as Daimler and Volvo have joint agreements in place in these regions,

[136] ACEA, 2021. EU motor vehicle exports, top 10 destinations (by value).
[137] Eurostat, 2021. Extra-EU trade of machinery and transport equipment (SITC 7) by partner [EXT_LT_MAINMACH]
[138] UNEP, 2020. Global Trade in Used Vehicles Report
[139] See Annex 8: Alternative set of assumptions on emission limits and durability for more details
[140] ICCT, 2015. Overview of the heavy-duty vehicle market and CO_2 emissions in the European Union
[141] Roland Berger, 2017. Truck and trailer components – Success factors for suppliers in specialized markets

which are securing them market access.[142]

Trade partners that are currently of somewhat less importance for the EU when it comes to trade of vehicles, but are expected to become more relevant in the near future include India and the ASEAN countries. The vehicle fleet in these countries has so far been relatively small in comparison to their respective populations. For example, in 2019 only 18 out of 1 000 Indians own a car, compared with nearly 500 in the European Union.[143] However, these fleets are growing rapidly, creating growth potential for European manufacturers[144].

Most of these trade partners have adopted rules of vehicle emissions that are in line with or more ambitious than the current Euro 6/VI vehicle emission standards. In addition, key markets China and the United States plan more demanding vehicle emission standards. While the China 6b emission standards for cars/vans (applicable in 2023), are already fuel-neutral and 40 to 50% more stringent than Euro 6/VI limits[145], China is progressing with an ambitious China 7 emission standards[146]. Also the US who has in place emission limits already well below the limits for almost all Euro 6 pollutants (Tier 3 Bin 30)[147] is currently working on a proposal for more stringent emission rules[148]. In August 2021, President Biden issued an Executive Order with the objective of making the US leader on clean and efficient cars and lorries by making 50% of all new passenger cars and light lorries battery electric, plug-in hybrid electric or fuel cell electric vehicles.[149] Under this Executive Order "the Administrator of the Environmental Protection Agency (EPA) shall, as appropriate and consistent with applicable law, consider beginning work on a rulemaking under the Clean Air Act […] to establish new multi-pollutant emissions standards, including for greenhouse gas emissions, for light- and medium-duty vehicles beginning with model year 2027 and extending through and including at least model year 2030." For heavy-duty vehicles, the order imposes the EPA to establish new oxides of nitrogen standards for vehicles with the same model years. Hence, global pressure to reduce transport emissions intensifies.

Japan's emission control requirements for vehicles are the strictest in Asia.[150] Other Asian trade partners have been following the Euro standards to mitigate vehicle pollutant emissions on their territory. South Korea has been following the European precedent for diesel vehicle emission standards since 2002 and the Euro 6 standard entered into force in 2020[151]. Since India is grappling with high pollution levels, it has adopted Euro 6 equivalent emission standards in 2020. In addition, ASEAN countries have adopted emission requirements based on the EU and Japanese rules. However, the specific Euro

[142] SWD(2018) 185 final Commission Staff Working Document, Impact Assessment on setting CO_2 emission performance standards for new heavy-duty vehicles: For example, Daimler holds a 90% stake in the Japanese company Fuso, which has a 24% share of the Asia-Pacific market

[143] Automotive News Europe, 2019. Why cracking India's booming car market is not so simple

[144] Automotive News Europe, 2020. Mercedes, BMW, others fear parts-rule hit in India

[145] CLOVE, 2022. Technical studies for the development of Euro 7. Testing, Pollutants and Emission Limits. ISBN 978-92-76-56406-5.

[146] European Commission – JRC, 2021. Sino-EU Workshop on New Emissions Standards and Regulations for Motor Vehicles

[147] ICCT, 2019. Recommendations for post-Euro 6 standards for light-duty vehicles in the European Union

[148] The Wall Street Journal, 2021. Biden Administration Moves to Unwind Trump Auto-Emissions Policy

[149] The White House Briefing Room, 2021. Executive Order on Strengthening American Leadership in Clean Cars and Trucks (August 05 2021)

[150] ICCT, 2021. Japan

[151] Transport Policy, 2021. South Korea: Light-duty emissions

standard differs between the different nations with ASEAN standards ranging from Euro 1/I to Euro 6/VI.[152] Singapore is the clear frontrunner, having already implemented Euro 6/VI in 2018.[153]

Norway, Switzerland, Turkey and the United Kingdom are all currently following the EU rules regarding the air pollutant emissions from vehicles. As member of the European Economic Area (EEA), Norway is obliged to implement the current and future Euro vehicle emission standards to ensure the functioning of the Single Market. Since Switzerland participates in the EU vehicle market, it has also adopted the EU legislation on vehicle emission standards. Turkey, who is a member of the EU Customs Union, but not of EEA or EFTA, is required to enforce rules on competition, product and environment that are equivalent to those in the EU in areas where it has access to the EU market. For the United Kingdom, a future mutual agreement shall have the ambition to continue the implementation of any future Euro standards in the country.[154]

1.5. Cumulative impacts on consumers, employment and industry competitiveness

1.5.1. Introduction

A Euro 7 emission standard for new vehicles would not stand alone, but would instead interact with other policies. The revised CO_2 emission standards for cars and vans[155] – presented on 14 July 2021 – are of particular relevance in this context. The proposed CO_2 emissions standards for cars and vans will accelerate the transition to zero-emission mobility by requiring average CO_2 emissions to come down by 55% for new cars and by 50% for new vans in 2030 (compared to 2021 levels) and by 100% for both categories in 2035. As a result, all new cars and vans registered as of 2035 should be zero-emission.

The CO_2 standards affect the European vehicle fleet and subsequently result in economic, environmental and social impacts. While most economic or social impacts associated with the policy options introduced in Chapter 5 are in most cases expected to be limited on their own, the cumulative impact – taking into account the effects of the CO_2 standards – could be more extensive. This section will dive into such impacts on consumers, employment and industry competitiveness.

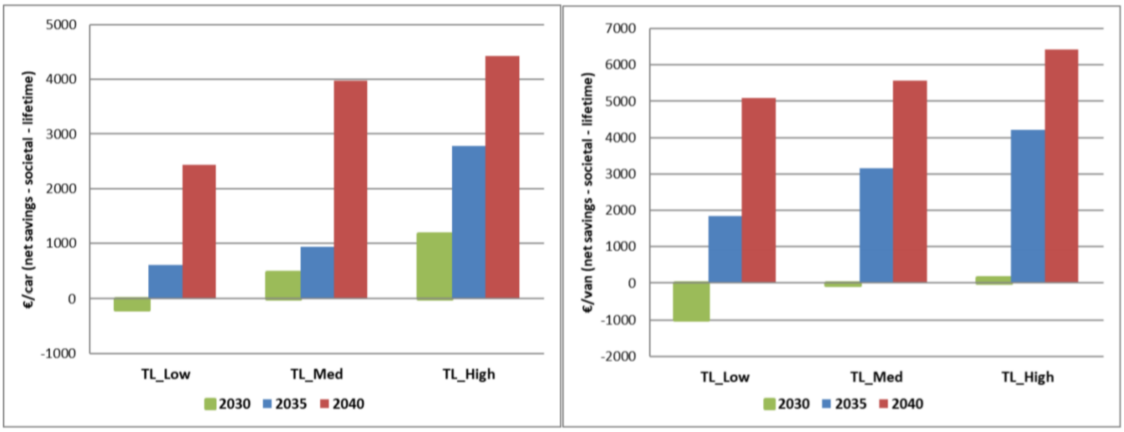
Since the recently proposed CO_2 standards only have implications for cars and vans and a revision of the CO_2 standards for heavy-duty vehicles[156] is only planned for 2022, this assessment will focus on the cumulative impacts in the cars and vans segments. Similarly, a revision of the Ambient Air Quality Directive is only planned for 2022, hence cumulative impacts through more local actions taken at Member State level such as city bans cannot be quantified yet. Still, an ambitious Euro 7 (and CO_2 standards) will help Member States meet current and future air quality targets (especially for NO_x and $PM_{2.5}$) and will contribute to the long-term reductions of these pollutants required by NECD.

[152] Fuels and lubes Magazine, 2019. ASEAN: a roadmap to Euro VI.
[153] Dieselnet, 2021. Standards: Singapore
[154] Institut for Government, 2020. Brexit Brief. Options for the UK’s future trade relationship with the EU
[155] COM(2021) 556 final. Proposal for a Regulation amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union’s increased climate ambition
[156] Regulation (EU) 2019/1242 CO_2 emission performance standards for new heavy-duty vehicles

The CO_2 impact assessment[157] looked into the net savings (i.e. net benefits) over the vehicle lifetime from a societal perspective for different CO_2 target level (TL) scenarios taking into account other policies including strengthening of the EU ETS (the possible emissions trading for buildings and road transport), the increased use of renewable fuels in road transport required under the Renewable Energy Directive and Euro 7 based on preliminary assumptions close to the current PO2a. **Scenario TL_High**, which is the closest scenario to the final adopted CO_2 proposal, in Figure 14 presents the results of the analysis for vehicles registered in 2030, 2035 and 2040. As a point of comparison, the same scenario in Figure 15 shows the net savings resulting solely from the CO_2 emission standards.

The figures illustrate that the average net savings of the TL_High scenario decrease when considering the cumulative impacts with Euro 7 and other policies, while still remaining positive. The CO_2 impact assessment indicated that the results in Figure 14 are primarily driven by a decrease in the energy savings due to higher electricity and fuel prices[158] following the revised EU ETS and Renewable Energy Directive and by an increase in avoided CO_2 emissions due to the combination of the policies.[159]

Figure 14 - Average net savings over the vehicle lifetime from a societal perspective (EUR/vehicle) resulting from the combination of policies (cars (l) and vans (r)) (see scenario TL_High)[160]



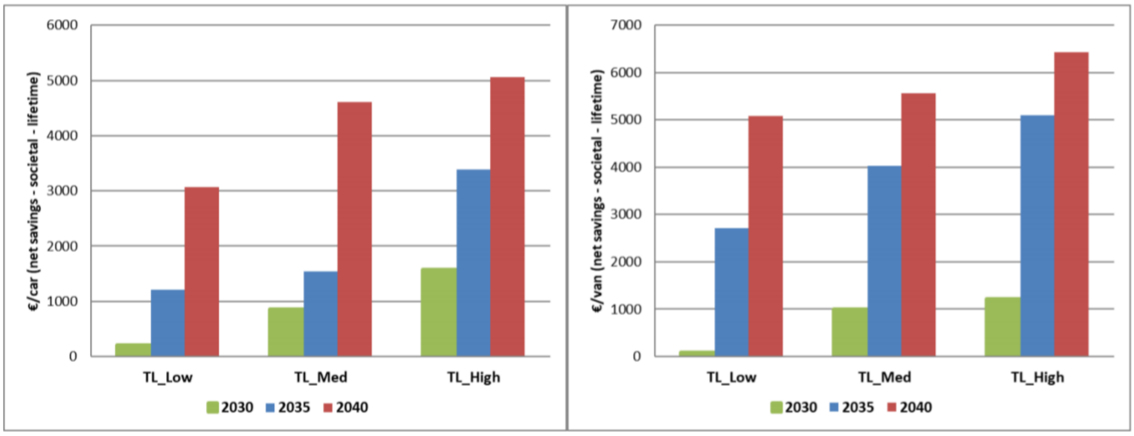
[157] SWD(2021) 613 final, Commission Staff Working Document, Impact Assessment, Accompanying the document Proposal for a Regulation amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition

[158] Where the Euro 7 impact assessment considers the regulatory costs of manufacturing and type-approving a new vehicle regarding pollutant emissions, the CO_2 impact assessment analysed the total cost of ownership also taking into account possible fuel savings for consumers which are not relevant following more stringent air pollutant emission standards.

[159] See footnote 157

[160] See footnote 157

Figure 15 - Average net savings over the vehicle lifetime from a societal perspective (EUR/vehicle) resulting from the CO_2 emission standards (in a MIX policy scenario context) (cars (l) and vans (r)) (see scenario TL_High)[161]



1.5.2. Cumulative impacts on consumers

When considering the impact of a 100% CO_2 target for cars and vans in 2035 on consumers, it is not solely the vehicle prices that are of concern. Since fuel and electricity savings from the use of zero-emission vehicles are significant for the consumers and exceed the higher upfront costs of more efficient and zero- and low-emission vehicles, the newly introduced CO_2 emission standards are expected to decrease the total cost of ownership (TCO) of such vehicles.[162] The third column in Table 32 shows the average net savings in TCO resulting from the CO_2 emission standards in Scenario TL_High from a first end-user perspective[163] in considering the first five years of a vehicle's lifetime for a new vehicle registered in 2030, 2035 and 2040.

With new internal combustion engine (ICE) cars and vans (including hybrids) still being introduced in the EU fleet until 2035, it is of interest to assess the effect of the different Euro 7 policy options on the net savings in TCO achieved through the new CO_2 standards. In addition, the two sets of limits introduced for brake emissions in PO2a, PO2b and PO3a also apply to zero-emission vehicles.[164] Therefore, the policy options are also expected to affect the TCO for cars and vans in 2035 and 2040.

To make the assessment, the total costs of the policy options in 2030, 2035 and 2040[165] were split up for cars and vans and divided by the new vehicle registrations expected in the respective year and segment taking into account the fleet developments. That way, fleet average costs per vehicle were calculated in line with the approach in the Impact

[161] See footnote 157
[162] See footnote 157
[163] While the CO_2 impact assessment also inspects the impacts on the total cost of ownership from the second user perspective, for this assessment an analysis of the first user perspective is deemed sufficient. The Euro emission standards mostly affect consumer affordability and the cost of ownership through the impact on the price of vehicles for first users. Impacts on the second users market will be limited since the increase is expected to be only a fraction of the price for first users, for all options.
[164] As illustrated in Table 20, the costs for including brake pads and filters to bring down harmful brake emissions is not the same for vehicles that are or are not primarily equipped with an internal combustion engine. Reason for this being that regenerative braking allows for reaching the brake emission limits at a lower cost per vehicle for PHEV and EVs.
[165] Supporting Impact Assessment Study, chapters 5.1.2, 5.2.2. and 5.3.2. Economic impacts

Assessment on CO_2. These costs per vehicle were subsequently subtracted from the net savings achieved by the CO_2 standards. The results for all policy options are presented in Table 32.

Table 32 – Cumulative impact of CO_2 standards (Scenario TL_High) and the Euro 7 policy options on the total cost of ownership (TCO) first users of new cars and vans

year	*vehicle*	**Net savings in total cost of ownership (TCO) first users of new cars and vans**				
		Only CO_2 standards[166]	CO_2 standards and PO1	CO_2 standards and PO2a	CO_2 standards and PO2b	CO_2 standards and PO3a
2030	€ per car	600	587	486	356	488
	€ per van	600	526	342	236	345
2035	€ per car	2 200	2 200	2 185	2 131	2 185
	€ per van	4 000	4 000	3 985	3 931	3 985
2040	€ per car	3 100	3 100	3 088	3 043	3 088
	€ per van	5 500	5 500	5 488	5 443	5 488

The table shows that the 1.7-2.3% increase in diesel vehicle prices in PO2a, PO2b and PO3a due to the mounting of pollutant emission control and sensor technology leads for the consumer to a decrease of the TCO savings from €600 per 2030 car when only the effect of the CO_2 emission standards is taken into account to €356-€488 per 2030 car when additionally the effect of PO2a, PO2b and PO3a are taken into account. For vans the decrease in savings is more extensive moving from €600 per 2030 vans to €236-€345 for PO2a, PO2b and PO3a. From 2035 on PO2a, PO2b and PO3a continue to have a small impact on the TCO for the consumer through the costs associated with complying with the limits for brake emissions for zero-emission vehicles. In 2035, TCO savings are expected to decrease from €2 200 per car - when only the effect of the CO_2 emission standards are taken into account - to €2 131-€2 185 - when additionally the effect of PO2a, PO2b and PO3a are taken into account. For vans, these policy options are expected to lead to a decrease in TCO savings from €4 000 to €3 931-€3 985 per van. Following learning effects related to hardware costs (see Annex 4 chapter 1.3), this impact is expected to further decrease in 2040.

Even though the policy options are expected to decrease the net savings in TCO for first users of new cars and to a larger extent for new vans, the overall cumulative effect of the CO_2 standards and the large share of policy options is still expected to be positive for the European consumer.

Considering the high regulatory costs for PO2b and cumulative impacts on consumers with the CO_2 emission standards, PO2a and PO3a are considered most proportionate for cars and vans to reach the zero-pollution and climate ambition of the European Green Deal.

1.5.3. Cumulative impacts on employment

In the CO_2 impact assessment[167], macro-economic models (i.e. E3ME and GEM-E3) were used to quantify the impacts of the targets on the wider economy, including employment. The new CO_2 standards for cars and vans were found to positively affect

[166] See footnote 157
[167] See footnote 157

the economic-wide GDP and employment due to the significant sector transformation from combustion-engine to zero-emission vehicles. The number of jobs are expected to increase by 39 000 in 2030 (0.02% increase in all relevant sectors) and by 588 000 in 2040 (0.3% increase in all relevant sectors) in Scenario TL_High.[168]

Since the Euro 7 policy options are generally based on existing technologies that do not require sector transformation, their impacts on GDP, sectoral output and employment are expected to be limited. In particular, the average annual additional investments (see also section 1.5.4) to reach the 100% CO_2 target in 2035 are estimated to amount up to €19 billion between 2021 and 2040. The Euro 7 policy options, however, are estimated to only result in average annual investments of €0.2, €1.2 or €2.4 billion during this same period (see Table 33 below). Hence, the policy options require investments one to two orders of magnitude below the investment required for CO_2. Since investments of this size are not likely to have any appreciable macroeconomic impact, the impacts on employment in Chapter 6 have been evaluated in a qualitative manner.

While PO1 and PO2a are expected to have a neutral impact on employment (i.e. no appreciable differences are expected), the qualitative assessment in Chapter 6 expected the more ambitious to have a low positive impact over the period 2025-2050. Indicatively, a low positive impact in employment was expected to correspond to far less than 0.1% of jobs concerned. The International Energy Agency has estimated that for every $1 million investment in ICE car manufacturing 5.2 to 9.2 jobs are created.[169] Taking into account that such employment multipliers are usually at the lower side for more advanced economies[170], the annual investment in 2030 of €1.5 billion for PO3a and of €2.5 billion for PO2b could approximately lead to 9 161 – 15 269 jobs[171].

Taking into account the estimated positive impact of the CO_2 standards and the low positive impact of PO2b and PO3a, the cumulative impact on the number of jobs in 2030 could be approximated by an increase of 0.024-0.027%. This translates in a total increase in the number of jobs of 48 161 – 54 269 in 2030.[172] Hence, the cumulative impact of CO_2 and the Euro 7 policy options on employment is expected to be limited with positive impacts mainly seen in the sectors supplying to the automotive sector as well as in the power sector. Other sectors experience some positive second order effects, e.g. as a result of overall increased consumer expenditure. Despite this estimated growth in employment, the impact assessment still foresees a loss in jobs in sectors associated to the production of internal combustion engines. Therefore, a certain level of reskilling of workers will be necessary to facilitate the sectoral transition.[173]

1.5.4. Cumulative impacts on industry

In the context of industry competitiveness, it can be interesting to look into the cumulative investments to comply both with the 100% CO_2 targets for cars and vans in 2035 and the policy options considered for a Euro 7 standard for these vehicles. Table 33 presents additional the average annual investments associated to the new CO_2 standards

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[168] See footnote 157
[169] IEA, 2020. Sustainable Recovery World Energy Outlook Special Report: Transport
[170] IMF, 2021. The Direct Employment Impact of Public Investment.
[171] Considering the EUR/USD exchange rate of 17 August 2021 recorded at 1.1745.
[172] These numbers are merely indicative considering the difficulties in modelling macroeconomic impacts of this magnitude.
[173] See footnote 157

over the baseline in Scenario TL_High for the period 2021-2030 and 2021-2040 in billion euro[174] as well as the cumulative investments for the CO_2 standards and PO1, PO2a, PO2b and PO3a respectively.

Table 33 - Average annual additional investments over 2021-2030 and 2021-2040 in € billion (in 2021 values) (Scenario TL_High for CO_2 standards) [175]

	Period 2021-2030	Period 2021- 2040	% increase of PO on additional cost 2021-2040
Only CO_2 standards[176]	**2.6**	**19.0**	**NA**
CO_2 standards and PO1	3.0	19.2	1%
CO_2 standards and PO2a	4.6	20.2	7%
CO_2 standards and PO2b	6.2	21.4	13%
CO_2 standards and PO3a	4.6	20.2	7%

The table illustrates that in period 2021-2030 for all policy options, expect for PO1, similar or higher average annual investments are expected than for meeting the new CO_2 targets (€2.6 billion). This can be explained by the fact that most regulatory costs associated to Euro 7 will occur closely after 2025. For the CO_2 standards, on the other hand, the most stringent target of 100%, will only come into force in 2035.

For 2021-2040, the average annual investments induced by the new CO_2 standards increase to €19 billion. The annual increase of the Euro 7 policy options varies from €0.2 billion for PO1 to €2.4 billion for PO2b, further increasing the annual investments by 1-13%. In total, the average investments over 2021-2040 increase from €19 billion for the 100% CO_2 target in 2035 to €19.2-€21.4 billion when the effect of PO1, PO2a, PO2b and PO3a are taken into account.

This investment challenge for the automotive sector to reach the climate and zero-pollution ambition was already recognised in the European Green Deal[177], which stated that “Delivering additional reductions in emissions is a challenge. It will require massive public investment and increased efforts to direct private capital towards climate and environmental action, while avoiding lock-in into unsustainable practices. […] This upfront investment is also an opportunity to put Europe firmly on a new path of sustainable and inclusive growth. The European Green Deal will accelerate and underpin the transition needed in all sectors.” Clear regulatory signals to the automotive sector are considered crucial for delivering climate and zero-pollution investment decisions.

Another important aspect to assess are the cumulative impacts on international competitiveness. As cleaner technologies have developed rapidly, new players focusing on clean vehicles have emerged across the globe, some of which have started entering the EU market. Policy developments towards have been a key driver for investments in zero-emission and zero-pollution technologies. Hence, the cumulative investments are expected to lead to benefits for the competitiveness of the automotive industry in a context where zero-emission and zero-pollution technologies will be more and more

[174] See footnote 157
[175] Calculated based on Table 4, Table 6 and Table 9 in Chapter 6
[176] See footnote 157
[177] COM(2019) 640 final. The European Green Deal

demanded on the global market.

Figure 12 (Annex 4 Chapter 1.4.1.) illustrates that after the UK, the United States and China represent two of the biggest export markets for the EU automotive industry with 1 million and 460 000 cars exported in 2019 to the US and China respectively, resulting in €59 billion.[178] The United States recently re-joined the Paris agreement and currently works on a proposal for more stringent emission rules. China is progressing with an ambitious China 7 emission standards and recently pledged to achieve climate neutrality by 2060. They can be expected to continue to accelerate the deployment of zero-emission vehicles through regulatory action and to tackle the serious air quality concerns in cities.

Next to China, East Asian countries South-Korea and Japan make up for a smaller 7 and 5 percent of the EU export in cars in 2019. Both countries have proclaimed their ambitions to cut greenhouse gas emissions in the coming years to achieve carbon neutrality by 2050.[179][180] While South Korea has been following the European precedent for diesel vehicle emission standards since 2002 and the Euro 6 standard entered into force in 2020[181], Japan's emission control requirements for vehicles are the strictest in Asia.[182]

Also Norway, Switzerland, Turkey and, more recently, the United Kingdom are important destinations for European car exports. In 2019, 2.2 million motor vehicles (including also heavy-duty vehicles) were exported from the EU-27 to the United Kingdom, representing 30% of the total EU vehicle exports.[183] While these nations have put together action plans towards battling climate change, all of them follow the current EU rules regarding the emissions from cars and vans and are expected to continue to do so (see 1.4.1.).

Trade partners that are currently of somewhat less importance for the Union, but are expected to become more relevant in the near future for cleaner vehicles include India and the ASEAN countries. The vehicle fleet in these countries has so far been relatively small in comparison to their respective populations. However, they are growing rapidly, making them a possible export destination for European manufacturers. Since India and most ASEAN countries are grappling with high pollution levels, they have adopted Euro emission standards. On the other side, nations like India are expected to be slower in bringing fully electric vehicles to the market considering their higher cost and will instead focus on compressed natural gas and hybrid vehicles for at least another decade.[143,144]

Taking into account all of the above developments, stimulating innovation in zero-emission technologies as well as in pollutant emission control and sensors technology the EU would allow access to international markets to be maintained while improving the competitive position of the EU automotive sector over the baseline.

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[178] ACEA, 2020. EU passenger car exports, top 10 destinations (by value)
[179] AP News, 2021. Japan raises emissions reduction target to 46% by 2030
[180] European Parliament Think Tank, 2021. South Korea’s pledge to achieve carbon neutrality by 2050.
[181] Transport Policy, 2021. South Korea: Light-duty emissions
[182] ICCT, 2021. Japan
[183] ACEA, 2020. EU-UK Automobile Trade: Facts and Figures

2. BASELINE

Since the Euro 6/VI evaluation and the Euro 7 impact assessment were performed in parallel, two baselines have been considered to assess on the one hand the achievements of the current Euro 6/VI standards and on the other hand the impacts of a new initiative.

2.1. Evaluation Baseline

In the Euro 6/VI evaluation (see Annex 5) which covers the time period 2013/2014 until 2050, the proposed baseline represents what would have happened in the absence of the intervention. Without the introduction of Euro 6/VI emission standards, the previous emission standards – Euro 5 for cars and vans; and Euro V for lorries and buses – would have remained in place (see Annex 5, Table 35).[184] More specifically, the following assumptions were made in the evaluation baseline[185]:

For cars and vans, the baseline assumes that Euro 5 standards would remain in place and that, in the absence of the Euro 6 intervention, there would have been no further changes to pollutant emissions limits for new vehicles and no further changes to the relevant testing procedures.

However, the evaluation analysis also examined a second Euro 6 pre-RDE baseline for cars and vans. Considering the specific implications of the stepwise process of the Euro 6 implementation and, in particular, the significant changes to the testing procedures introduced with the adoption of RDE testing in the wake of Dieselgate, this second baseline reflects the evolution of the legal framework up to the point of the introduction of RDE testing. Hence, the Euro 6 pre-RDE baseline corresponds to the Euro 6b/c standards and assumes that RDE testing would not have been introduced. Therefore, the analysis examines the impacts that are only associated with the introduction of RDE testing in Euro 6d(-temp).

For lorries and buses, the continuation of the Euro V standard is assumed. As such, the assumption is that there would be no further changes to the emission limits or testing requirements. All new lorries or buses entering the market after 2013 would be Euro V vehicles. In this case, no additional changes to the testing procedures are considered as part of the baseline.

Next to the assumptions related to the Euro standards, the evaluation baseline considers the following key policy developments:

- CO_2 standards for cars and vans (Regulation (EC) No 433/2009 and (EU) No 510/2011, both since 1 January 2020 repealed and replaced by Regulation (EU) 2019/631) and for heavy-duty vehicles (Regulation (EU) 2019/1242). This development has led to the adoption of new technologies to achieve fuel efficiency and the reduction of greenhouse gas emissions. Hence, these standards are assumed to have affected the share of new diesel vehicles and the vehicle fleet in general.
- Relevant national policies, for instance on the development of low-emission zones (LEZ). In the baseline it is assumed that LEZs would have been based on the most recent standard, which would have been Euro 5/V in the absence of Euro 6/VI.

[184] CLOVE, 2022. Euro 6/VI Evaluation Study. ISBN 978-92-76-56398-3, chapter 2.6 Baseline definition and point of comparison.
[185] See footnote 184.

The baseline for the evaluation makes the assumption that in the absence of the Euro 6/VI emission standards, vehicle manufacturers would not have introduced technologies to decrease pollutant emissions beyond what was required in the Euro 5/VI standards. Considering the cost of emission control technologies, supported by evidence gathered during the Dieselgate, it is not expected that any of the external trends would have resulted in manufacturers voluntarily adopting additional technologies. In contrast to the CO_2 emissions standards where fuel efficiency represents a possible purchase criterion for consumers, differences in the pollutant emissions levels are not expected to significantly drive consumer choices.

Next to its impact on policy developments, Dieselgate is also assumed to have had an impact on consumer awareness in the baseline, especially when it comes to pollution resulting from diesel vehicles. Between 2015 and 2018, the share of diesels sold in the EU (as a percentage of the total market for new passenger cars) declined from 52% to 36%.[186]

The evolution in the cost of raw materials is also relevant in terms of the costs of emission control technologies, particularly for precious metals such as palladium or rhodium which are used in catalytic converters. These raw materials have seen a significant increase in unit price since 2015, which is also taken into account in the baseline.

The macroeconomic assumptions for the baseline scenario follow the macroeconomic trends over the evaluation period. During this time period, the EU experienced a small but positive growth rate (in the range of 1.5-3% per year)[187] following the decline during the financial crisis. The number of new vehicle registrations also increased on an annual basis since 2013 following the significant decline in the 2008-2013 period.[188] In addition, the impact of COVID-19 is also included in the baseline and will be further discussed in Annex 6.

At the time of the adoption of Euro 6/VI, there were significant air quality problems throughout the EU, especially in urban areas and in densely populated regions. Road transport was responsible for a significant share of this pollution problem. According to the Euro 6/VI impact assessments, it contributed to 43% of total NO_x emissions, and 27% of total volatile organic compounds (VOCs) in 2002. In the Euro 5/V evaluation baseline, however, Euro 6/VI would not have entered into force which means that all new vehicles entering the market since 2014 (in the case of Euro 6) and 2013 (in the case of Euro VI) would have continued to be type-approved under the Euro 5/V standards. In the case of the Euro 6 pre-RDE baseline, Euro 6d(-temp) would not have been adopted, meaning that all cars and vans entering the market since 2018 would have continued to be type-approved under Euro 6c.

On the basis of the assumptions for the evaluation baseline, the SIBYL and COPERT models were used to develop projections of the expected evolution of the key variables in the baselines, including the evolution of new vehicle registrations and the evolution of emission factors per Euro standard/step.

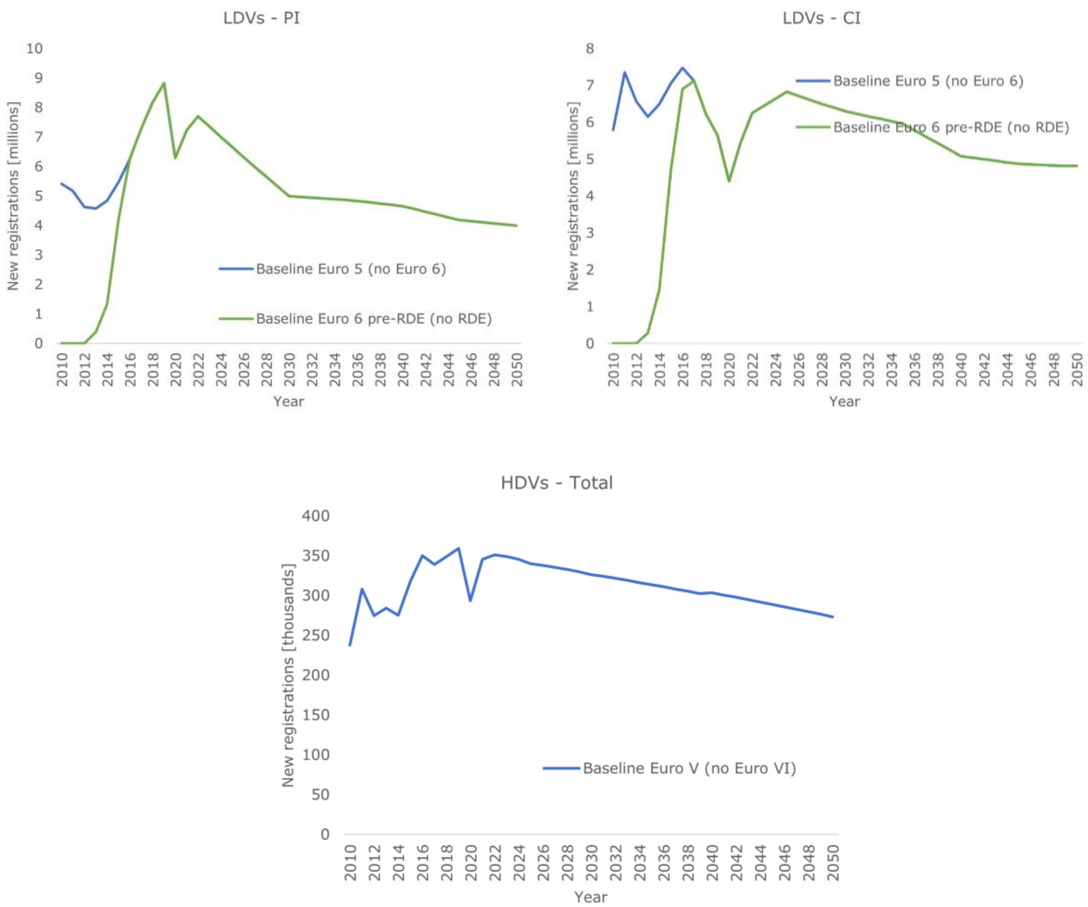
The number of new vehicle registrations under Euro 5/V or Euro 6b and its evolution

[186] ACEA, 2019. Share of Diesel in New Passenger Cars
[187] Eurostat, 2021. Real GDP growth rate - volume [TEC00115]
[188] OECD, 2019. Passenger car registrations Total, Percentage change

based on the SIBYL model are presented in Figure 16. For cars and vans, the blue curve represents the number of new registrations under the Euro 5 baseline, while the green curve represents the registration under the Euro 6 pre-RDE baseline. After 2018, the two curves converge since the total number of new vehicles registered coincide at that point in both baselines. The figures show that the number of new diesel and petrol cars and vans was expected to decline over time as more vehicles with an alternative powertrain (e.g. electric and hybrid vehicles) will enter the European fleet. This is effect is less for lorries and buses for which the number of new registrations of traditional vehicles are projected to remain stable.

The emission factors for each regulated air pollutant are expected to remain the stable over time (within a margin of error) for each vehicle category. Equation 1 demonstrated that the values for the emission factors are used to calculate the total emissions of a specific pollutant by multiplying the values with the number of vehicles in operation and the annual mileage per vehicle. The emission factors as used in the COPERT model for both the baseline and the evaluated Euro 6/VI standard are summarized in Table 7 in section 1.2.[189]

Figure 16 - Expected evolution in the number of new vehicle registrations under the Euro 5/V and the Euro 6 pre-RDE baseline[190]



[189] Emission factors for PN are not provided, due to the lack of such data in COPERT and because of the lack of trustworthy test data.

[190] CLOVE, 2022. Euro 6/VI Evaluation Study. Annexes 1:6 ISBN 978-92-76-56522-2. Annex 2: Development of the baseline scenarios, 9.2.6 Evolution of key pollutants.

2.2. Impact Assessment Baseline

The baseline to assess impacts of the policy options takes the following into account: a) the Euro 6/VI emission standards, b) the impact of COVID-19 on road transport activity[191] and c) the impact of the new 55% (cars) and 50% (vans) CO_2 targets by 2030 and 100% CO_2 targets for cars and vans by 2035[192] and the projected fit-for-55 HDV fleet evolution to contribute to the 55% net greenhouse gas emission reduction by 2030 and the 2050 climate neutrality objective[193] .

The baseline cannot take into account the effect of future potentially more stringent air quality targets which may trigger more city bans of combustion-engine vehicles and therefore modify road transport activity or vehicle sales. Such possible effect of future air quality targets would be difficult to quantify since it will depend on local actions taken at Member States level and will not be uniformly applied throughout the EU. However, this additional effect from the planned revision of Ambient Air Quality Directive in 2022 is estimated limited compared to the effects of CO_2 emission standards.

The baseline is a "no policy change" scenario which implies that the relevant EU-level legislation, addressing air pollutant emissions resulting from road transport will continue to apply without change. That means that Euro 6/VI applies, taking into account impact of the CO_2 targets for vehicles, including the aforementioned new CO_2 targets for cars/vans, and COVID-19 on road transport activity. It is referred to in chapter 6 as the baseline.

a) Euro 6/VI emission standards

The provisions laid down in the Euro 6/VI emission standards[194] and in particular the air pollutant emission limits and real-driving testing conditions set out therein are summarised in Annex 5, Table 34 and 35). This is the relevant EU-level legislation to reduce air pollutant emissions from road transport in Europe, which is assumed to remain in force.

Over time fleet renewal would lead to an increased share of Euro 6/VI vehicles in the EU fleet. As only 20% of cars and vans, and 34% of lorries and buses are type-approved to Euro 6/VI in 2020, including RDE testing for cars and vans introduced under final Euro 6d step, the benefits of cleaner Euro 6/VI vehicles compared to previous Euro vehicles will continue to be felt in the next decades on EU road as older vehicles are replaced by

[191] Road transport activity is the volume-km driven by vehicles on EU roads and is projected by the estimated evolution of vehicle sales.

[192] A linear interpolation was used for the year 2030 for both the activity and shares of vehicles between the two existing scenarios in the CO_2 Impact Assessment (TL_Med and TL_High), while the TL_High scenario was used for the year 2035. This approach is the estimated representation of the impact of the Commission proposal for CO_2 targets for cars/vans.

[193] For heavy-duty vehicles, the activity and fleet shares of vehicles are based on the SWD(2020) 176 final, Impact Assessment on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people (part 1) and SWD(2020) 176 final (part 2), supplemented for buses by CLOVE, 2022.

[194] Regulation (EC) No 715/2007 on type-approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6) and its implementing Regulation (EU) 2017/1151; Regulation (EC) No 595/2009 on type-approval of motor vehicles and engines with respect to emissions from heavy-duty vehicles (Euro VI) and its implementing Regulation (EU) No 582/2011

these new cleaner vehicles[195].

b) Impact of COVID-19 on automotive industry and of transport activity

The COVID-19 pandemic continues to have significant effects on the automotive sector, which have the potential to shape the sector for years to come. In the short, the sector has been affected by the containment measures and other restrictions throughout this period (e.g. full-scale lockdowns) as well as uncertainty about the future which had an unprecedented impact on car sales across the EU.

In the first six months of 2020, EU-wide cars and vans production losses due to COVID-19 related factory shutdowns amounted to more than 3.5 million vehicles, around 20% of total production in 2019. Following the trend of the EU's GDP, demand for new passenger and commercial vehicles dropped by respectively 23.7% (to 9.9 million units) and 18.9% (to 1.7 million units) in 2020 as a direct result of the pandemic.[196] The long-term effects on the industry will only become clear after the pandemic has come to an end and will largely depend on the pace of the economic recovery. EU economic activity is set to pick up again in the first half of 2021[197], but it may remain constrained by virus containment measures. Similarly, EU automotive manufacturing should continue to recover in 2021, provided that supply chains remain functional. Demand, however, is only expected to return to the 2019 levels by 2023.[198] Please see Annex 7 for more details on the impact of COVID-19 on automotive industry.

The baseline takes into account the indirect impact of the COVID-19 pandemic on vehicle emissions, mostly through its effect on transport activity and fuel consumption. Estimations from the impact assessment on the 2030 climate target plan[199] estimated that the projected decrease in total fuel consumption of road transport was about 17% in 2020 compared to 2019. In addition, the JRC estimated that between February and April 2020 a total drop in vehicle activity of 60-90% was realised for passenger cars compared to a 15% drop for freight transport.[200]

Based on this evidence and taking into account the impacts of COVID-19 on GDP[201], the impact of the pandemic on activity in the different vehicle segments has been estimated over the time period considered in the baseline. The short-term estimates point to a sharp activity drop of 15% in 2020, followed by significant recovery in 2021. Nevertheless, by 2030 the pandemic and following crisis are projected to result to a permanent loss in total activity of 6% compared to the pre-COVID levels. Figure 7 in chapter 5.1 presents the comparison of the evolution in transport activity taking into account the COVID-19 drop. Moreover, a decreased transport activity is assumed by promoting public means of transport over private vehicles and advancing modal shifts to other transport means than road transport, especially when it comes to passenger transport.[202] The total activity for

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[195] CLOVE, 2022. Euro 6/VI Evaluation Study. ISBN 978-92-76-56398-3, chapter 5.1 Effectiveness, Evaluation question 1.

[196] ACEA, 2021. Press release: Passenger car registrations: -23.7% in 2020; -3.3% in December 2020; ACEA, 2021. Press release: Commercial vehicle registrations: -18.9% in 2020; -4.2% in December 2020

[197] European Commission, 2021. Spring 2021 Economic Forecast: Rolling up sleves

[198] BCG, 2020. COVID-19's Impact on the Automotive Industry

[199] SWD(2020) 176 final, Impact Assessment on Stepping up Europe's 2030 climate ambition: Investing in a climate-neutral future for the benefit of our people (part 1) and SWD(2020) 176 final (part 2)

[200] JRC, 2020. Future of Transport: Update on the economic impacts of COVID-19

[201] See footnote 199

[202] See footnote 199

passenger transport in 2050 is projected to 6.4% lower, whereas the activity levels for freight transport are not assumed to differ.

c) CO_2 emission performance standards

The CO_2 emission performance standards[203] for light- and heavy-duty vehicles are a relevant EU-level measure which also reduce air pollutant emissions. This is due to the increased sales of zero- and low-emission vehicles that are triggered by stringent CO_2 targets for light- and heavy-duty vehicles. Battery and fuel cell electric vehicles do not have tailpipe emissions of air pollutants such as NO_x and particles but do emit non-tailpipe particles from brakes and tyres. Low-emission vehicles, such as plug-in hybrids, also have less tailpipe air pollutant emissions.

The CO_2 targets, including the new CO_2 targets proposed for cars/vans and the fit-for-55 projections for heavy-duty vehicles, and their impact on the vehicle fleet, are included in the Euro 7 baseline. As can be seen in Figure 7 in chapter 5.1, the share of new zero- and low-emission vehicles in the European vehicle fleet is projected to increase substantially over time, for light-duty vehicles much faster than for heavy-duty vehicles up to an end-date of 2035 for placing new combustion-engine cars and vans in the EU market.

[203] COM(2021) 556 final. Proposal for a Regulation amending Regulation (EU) 2019/631 as regards strengthening the CO_2 emission performance standards for new passenger cars and new light commercial vehicles in line with the Union's increased climate ambition, Regulation (EU) 2019/1242 CO_2 emission performance standards for new heavy-duty vehicles