Notes on the revision of the EU CO_2 emission performance standards for cars and light commercial vehicles

Submitted by Agora Verkehrswende in response to the public consultation of the European Commission

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Agora Verkehrswende
Smart Energy for Europe Platform (SEFEP) gGmbH
Anna-Louisa-Karsch-Str. 2
D-10178 Berlin

Phone +49 (0)30 7001435-000
Fax +49 (0)30 7001435-129
info@agora-verkehrswende.de

1 Key messages

We identify eight main findings that are relevant to the revision of the CO_2 standards for light-duty vehicles (Regulation (EU) 2019/631).

1. **Tighten the CO_2 limit value for 2030 considering values of up to 75%.** This is twice the current value of a 37,5% reduction compared to 2021, and substantially above the 50% that the Commission has mentioned in the Climate Target Plan. This faster improvement pathway is necessary in view of the climate neutrality target year of 2050 as well as the raised climate target for 2030. The impact assessment should also **analyse significantly higher values for 2030, up to 100%, i.e. a complete phase-out of combustion engines. A phase-out should take place by 2035 at the latest.**
2. **Adjust the limit value for 2025 in view of the tightened value for 2030.** Otherwise, the annual improvement rate after 2025 would be disproportionately high compared to the time period before. Also, the vehicles brought to the market until 2025 will remain on the road for many years, thus giving rise to an emission rucksack that should be minimized in line with the raised ambition of the EU Green Deal.
3. **Introduce limit value pathways over time after 2025.** The current format of constant limit values that are changed in a step-wise fashion at roughly five-year intervals is no longer adequate in an era of steep cuts. It motivates last-minute improvements, thus delaying action and implying higher cumulative emissions. Adjusting the limit values on a year-by-year basis gives a clearer signal and is more in line with the market introduction of new technologies, possibly assisted by new forms of flexibility such as credit banking for overachievement.
4. **Introduce supplementary limit values for combustion cars only.** Otherwise, there is a risk that the emissions from these cars would rise rather than fall in the future as the market share of zero emitting vehicles rises. A certain improvement rate should be set for these cars to ensure that the remaining low-cost options in emission reductions are realised.
5. **Do not account for fuels in the legislation of cars.** Allowing certificates for zero or low-carbon fuels to be used as a compliance option would undermine the technical improvement of cars. It would lead to a loss of credibility and transparency and to a mixing and confusion of regulatory fields of very different natures (vehicles and fuels). It would also increase the social costs of the legislation, interfere with the achievement of national targets under the Effort Sharing Regulation, and risk opening the door to unsustainable fuels. Finally, it is unlikely that a sufficient production capacity can be built up to make a real difference for the existing fleet, while using scarce low-carbon fuels in road transport would divert from sectors where no alternative is available, such as aviation and certain industries.
6. **Make the emission levels for plug-in hybrid vehicles (PHEVs) more realistic in the short term and in the longer term.** The available real-world studies suggest much lower electric usage in practice than assumed in the WLTP test and thus higher CO_2 emissions. On an interim basis, the utility factors to be used should be 50% of those coming out of the official test, until a complete revision of the testing regime can be carried out based on a more systematic collection of data.
7. **Drop the ZLEV factor.** While its effectiveness in promoting zero emitting vehicles is uncertain or even negative, it may lead to higher overall emissions of the fleet and it complicates the compliance mechanism, thereby obscuring public understanding. The strongest mechanism to motivate electrification is the tightening of the overall CO_2 limit value itself.
8. **The CO_2 emission standards for road vehicles must be complemented by energy efficiency standards at least for electric vehicles.** This should be considered already for the time after 2025 in view of the high anticipated rates of electrification. Even if a proposal cannot be prepared during the current revision for reasons of timing, the groundwork should be laid now so this transition can be achieved at a subsequent revision.

2 Introduction

The European Commission has published an Inception Impact Assessment[1] for an amendment of the EU Regulation on the CO_2 emission performance standards for cars and vans[2]. This amendment is one of the actions announced in the European Green Deal[3], adopted by the Commission in December 2019. As clearly laid out in the Inception Impact Assessment, road transport today accounts for a fifth of the EU's greenhouse gas emissions and has increased its emissions by over a quarter since 1990. Light duty vehicles (cars and vans) represent about 75% of total EU road transport CO_2 emissions, which in turn represent 70% of transport greenhouse gas emissions. Therefore, the emissions of light-duty vehicles must be further reduced in view of the EUs' objective of reaching climate neutrality in 2050 as agreed by the European Council[4].

This paper focuses specifically on the CO_2 standards for cars and light commercial vehicles, in response to the public consultation by the Commission. We do not enter here the question of how the car standards fit into the wider policy environment that is relevant for the decarbonisation of the transport sector and which includes the following instruments, among many more:

- Emission performance standards for road vehicles (cars, light commercial vehicles and heavy-duty vehicles)
- Legislation on fuels (the Fuel Quality Directive and the Renewable Energy Directive)
- Legislation on the required energy infrastructure (the Alternative Fuels Infrastructure Directive)
- The role of road transport in the context of the EU Emissions Trading System (ETS) and the question of whether and how road transport should be included into this system[5].
- Multiple further instruments that address the emissions of non-road transport modes, modal shift and demand management.

This overarching instrument architecture has to be addressed separately. In the present context we would only like to point out that there is a very strong case to be made for maintaining specific regulations for new car registrations irrespective of any integration of transport into the EU ETS because of a number of market imperfections that lead to substantial deviations from the text book economic theory as well as the risk of carbon leakage in in the industry sector.

2.1 Vehicle regulation in times of climate crisis

The current format of the legislation is based on policy guidelines that date from 2007 and whose main aim was to safeguard the competitive position of all manufacturers. At that time there was a profound unwillingness to even contemplate a reduction in the power, speed and size of cars. When these principles were formulated, climate change was seen as a more distant prospect in the public debate than today. The political pressure for change was more limited, so this reticence may be understandable. However, times have moved on. As this paper is being written, the impacts of climate change are becoming ever more visible – from the loss of Arctic sea ice to the melting of glaciers and permafrost and the worsening of droughts and wildfires. The Paris agreement in 2015 has changed the conversation and established a new climate governance; the world is now gearing up to achieving climate neutrality by mid-century. The youth protests of the Fridays for Future movement shook the political debate in 2019. According to a UNDP poll[6] in January 2021, 64% of people believe climate change is a global emergency, despite the

1 Ref. Ares(2020)6081912 - 29/10/2020
2 Regulation (EU)2019/631
3 COM(2019) 640
4 European Council (2019)

5 The issue is dealt with in a separate project conducted jointly with Agora Energiewende, ongoing. Relevant arguments can also be found e.g. in Öko-Institut and Agora Energiewende (2020), Chapter 8.2.
6 UNDP(2021)

ongoing COVID-19 pandemic, and rising numbers of local, regional and national governments declare climate change to be an emergency[7].

The strategic policy documents of the European Commission reflect this sense of urgency. The EU Green Deal notes that "*there is a need to rethink policies for clean energy supply across the economy*" and calls for "*transformational change*". The Sustainable and Smart Mobility Strategy[8] states that "*By far, the most serious challenge facing the transport sector is to significantly reduce its emissions and become more sustainable*" and points out that "*The success of the European Green Deal depends on our ability to make the transport system as a whole sustainable*". Noting that "*Greening mobility must be the new licence for the transport sector to grow*", the strategy concludes that "*Overall, we must shift the existing paradigm of incremental change to fundamental transformation.*" There has also been substantial technical progress, providing new and cheaper opportunities for switching to climate-friendly technologies and renewable sources of energy.

In such times, **the political guidelines laid down in 2007 must be reconsidered**. It can no longer be credibly argued that we can continue to build bigger, faster and more powerful cars while at the same time moving towards a sustainable world. That would clearly go against the policy priorities quoted above. Instead, we have to lay the groundwork for the inevitable transition towards an economy that is no longer based on limitless material growth but that has to reorient itself towards the satisfaction of needs and the maximization of well-being rather than consumption. This includes the types of vehicles to be used, including the question of whether there should be an upper limit to the emissions or the specific energy consumption that no vehicle can exceed.

Such a fundamental reorientation cannot be carried out as part of a technical review of the CO_2 standards, even if that review leads to an increase in stringency. It requires a broader discussion on the type of vehicles that are socially acceptable and compatible with a sustainable economy in the long term. We suggest developing a format for this kind of discussion and proceeding swiftly with initiating it, in the context of a wider debate on how we envision a sustainable and livable future for the EU. The outcome of that debate should come in time to inform the next revision of the CO_2 performance standards.

2.2 Strong indications for a rapid electrification of the light-duty vehicle fleet

The propulsion technology in road transport is currently undergoing a major transformation with the advent of electric drives. In September of 2020 the number of newly registered electric and plug-in passenger cars surpassed that of diesel-powered cars for the first time[9]. The CO_2 standards for light-duty vehicles have been among the principal drivers behind this development.

Based on the cost curves of the most recent impact assessment[10], it could have been expected that the OEMs would choose to improve combustion engines to emission levels considerably below 95g/km (under the NEDC cycle) before starting to switch to electric drives. From that point onwards they would proceed to electrify with little further improvement to combustion vehicles due to the nonlinear nature of the abatement cost curves for combustion cars. Instead, the manufactures have started to enter into a substantial amount of electrification already now when they have to meet the 95g/km limit value. The reasons may include characteristics of the market that prevent uptake of some of the abatement options for combustion vehicles (e.g. related to downsizing), incentives set by super-credits as well as reductions in the costs of

7 At the time of writing, the campaign Climate Emergency Declaration lists 1,867 jurisdictions and local governments that have done so. https://climateemergencydeclaration.org/climate-emergency-declarations-cover-15-million-citizens/

8 COM(2020) 789

9 JATO(2020)

10 SWD(2017) 650.

electrification that were faster than anticipated, but also strategic considerations linked to the inevitable need to electrify in view of future targets.

There are further indications that the switch towards electrification will have to take place faster than anticipated earlier. Together with two partner organisations we have recently concluded a major study[11] on a cost-effective pathway towards a climate-neutral Germany that also takes into account the new European mitigation target of 55 percent by 2030. In this study we found that the number of electric and plug-in hybrid cars on the road in Germany in the year 2030 would have to reach 14 million which represents roughly 30 percent of the entire vehicle stock. In order to reach this value, the combined market share of new electric and plug-in hybrid vehicles would have to reach almost 80% in 2030. Not only was this number not disputed by the industry, but it was instead confirmed by an independent paper[12] from the German agency in charge of planning the charging infrastructure. That paper, which is based on confidential input from the manufacturers, indicates a number of electrified vehicles on the road in 2030 of 14.8 million, even higher than what our own study has produced. On the EU level, a study conducted by the electricity industry anticipates 50-70 million electrified cars by 2030[13].

Overall, this points towards a **near-complete electrification of new registrations at some time between 2030 and 2035**. However, the legislation on the CO_2 emissions from light-duty vehicles was originally designed for a market largely made up of combustion-powered cars. Thus, it was essentially equivalent to a regulation on energy efficiency since the CO_2 emissions of a combustion powered car are closely correlated with the energy consumed[14]. The theory of change underlying the legislation was that combustion engines and powertrains would make use of a host of technological options to become gradually more efficient, as identified at length in the studies accompanying the legislative proposals and their impact assessments. In view of the new technology pathway that is now emerging, the legislation needs fundamental adaptation for two reasons.

1. The zero emission vehicles now entering the market are not regulated at all in terms of their energy efficiency. In view of the existing policies of the EU not only regarding energy efficiency but also resource efficiency, this is a policy gap. It also puts additional pressure on the electricity sector which will in any case have to be greatly expanded.
2. As rising numbers of zero emission vehicles enter the fleet, the emission limits on the remaining combustion cars become progressively less stringent and at some stage cease to be binding at all, as argued further below.

In the following chapters, we consider how the legislation could be adapted in order to deal with these issues.

3 Overall design of the legislative mechanism

3.1 Subject of the regulation: CO_2 emissions versus efficiency

Reducing the limit value for the average CO_2 emissions of the newly registered cars acts as a driver for electrification. However, as this trend becomes prominent, the regulation becomes less and less relevant to the fleet as a whole, since a shrinking number of vehicles actually emit CO_2. For those latter vehicles, the CO_2 limits become less binding with rising numbers of electric vehicles, as elaborated below (section 5.1), while the legislation does not establish any conditions for zero-emitting vehicles. In this situation, market forces are likely to lead to a fleet of

11 KNDE (2020)
12 Leitstelle Ladeinfrastruktur (2020)
13 https://www.eurelectric.org/connecting-the-dots/
14 With the qualification that petrol and diesel have different carbon content per volume and per unit of energy.

increasingly large, heavy and energy-consuming vehicles both on the combustion side and on the electric side. This would run counter not only to the original intentions of the legislation, which had energy efficiency implicitly in mind, but also to the spirit of the EU Green Deal and to the general sense that unfettered growth is incompatible with any notion of sustainable development, as outlined above.

Direct CO_2 emissions are not the only adverse impact to consider here. A key concern is the consumption of electricity, both from non-renewable and from renewable sources. The scarcity of renewable energy is sometimes put into question by pointing to the abundant amounts of solar and wind energy that are present in certain regions of the world. There is, however, a big difference between the amount of physical energy that is present in nature and the amount of renewable energy as a technical and commercial product that is available for consumption, mostly in the form of electricity. The former is indeed not scarce, but the latter is and will continue to be until the full decarbonization of the economy has been realized, and possibly beyond that point. In addition, the generation of renewable electricity is itself not free from environmental problems and requires scarce material resources. Other relevant aspects include the consumption of raw materials, microplastic pollution from tyre wear, and the non-emission impacts of road transport such as the competition for urban space. Also, safety risks increase with an ever-heavier vehicle fleet.

As a short-term stopgap, we propose a CO_2 limit value that applies to combustion cars only (see section 5.3). But this is insufficient in the longer term since, as argued below, the rate of electrification of new cars and light commercial vehicles will have to reach substantial proportions already after 2025, while a complete phase-out of combustion engines may take place by around 2035. Therefore, the current format of the legislation which was designed for a fleet of combustion cars will no longer be adequate as time progresses. Instead, as argued earlier[15], **it is advisable to prepare for a change towards regulating the energy efficiency of road vehicles rather than their tailpipe CO_2 emissions**.

For combustion cars, regulating the efficiency need not make any material difference because their CO_2 emissions and their energy consumption are closely correlated. The regulatory gap thus concerns electric vehicles in particular, which suggests the possibility of introducing **a new efficiency regulation for electric vehicles only while maintaining the existing legislation in its current format** at least in a transitional phase. The new regulation would act as a safeguard against the unrestricted growth in size and performance of electric cars that would otherwise risk counteracting the environmental advantage from introducing these vehicles in the first place. It would also reward those with more efficient technologies in view of the substantial differences seen in electric cars today both regarding drivetrain efficiencies and charging losses.

Changing the format of the legislation in this profound manner may not be feasible in the time available, since the EU Green Deal requires a proposal already by the summer of 2021. However, the groundwork should be laid by including a review clause in the proposal, for example for a new proposal by 2023 as originally foreseen in the legislation. In parallel, the necessary studies and stakeholder consultations should already be initiated.

3.2 Lifecycle emissions

The climate impact of road vehicles is not restricted to their use phase. Greenhouse gas emissions occur over the entire life cycle of the products, from mining and material production to the manufacture and finally the end-of-life phase. For combustion vehicles

15 Elmer(2016); Sachverständigenrat für Umweltfragen (2017); Hörmandinger (2019)

the total life cycle GHG footprint is clearly dominated by usage phase emissions. This is also true for electric vehicles with the current electricity mix, but here concerns have been raised specifically about the emissions during the manufacture of the vehicles.

It should be noted that the driving concern behind these proposals is the battery rather than the rest of the vehicle, looking not only at greenhouse gas emissions but also the environmental and social sustainability related to the production of some of the raw materials involved, notably Cobalt and Lithium. Due to rapid advances in battery manufacturing, the share of the battery in the greenhouse gas emissions from manufacturing electric vehicles has declined significantly[16]. Nevertheless, there have been proposals to include these emissions in the scope of the legislation on vehicles. The issues around batteries have been recognized as deserving serious consideration. It is in this context that the Commission has made a proposal for a battery Regulation[17] which is currently in the co-decision process. The noted concerns are thus taken care of separately. Including them in the legislation on cars as well would constitute double regulation.

One might ask whether the rest of the vehicle should not also be covered by a lifecycle approach. However, this would be problematic for a number of reasons. First, given globalized value chains, the data requirements of a comprehensive life cycle approach for entire vehicles, which are among the most complex consumer products, are huge. Information is needed on a large number of processes linked to resource extraction, materials processing, and manufacturing. The same holds true for disposal and recycling patterns as well as for processes in primary production that are substituted by recycled materials. In order to translate the energy consumption into GHG emissions, detailed information is needed not only about the energy intensities of all these processes but also about the electricity mix and the energy carriers used in the countries involved in the value chain.[18] In addition, the required information is dynamic as all actors involved in the system are continuously adapting their supply chains. Given that this information cannot be obtained accurately in the short and medium term, if ever, the upstream data would have to rely on default values. Using defaults, however, does not set incentives for CO_2–reducing innovations. Even if the quality of data could be improved over time, its gathering for the entire vehicle life cycle would involve a huge bureaucracy and overhead as well as establishing credible monitoring, reporting and verification systems overseas.

Second, the manufacturing as well as the end-of-life emissions of vehicles have a different character from the emissions during their operation, similar to the difference between fixed and variable costs in a purchase decision. The latter are widely variable depending on the usage, whereas the former are independent of the usage patterns. A combined metric that integrates all these stages can cause economically and environmentally adverse distortions – particularly if the metric is also used for consumer information purposes.

Third, consumers tend to insufficiently factor in future (energy) costs when making vehicle purchase decisions. This is one of the key rationales for imposing CO_2 standards, or fuel economy regulations in general, because they counteract this tendency and thus create net welfare benefits. This so-called myopia or undervaluation applies to the use phase of the vehicles but not to their manufacturing stage. Hence, standards for light-duty vehicles, as well as obligatory efficiency information based on them (e.g., fuel economy labels), should address cost components beyond the purchase price in order to help consumers making better decisions in terms of total cost of ownership. In contrast, the energy costs during the

16 See Ricardo AEA 2020, IVL 2019, Argonne National Laboratory 2019.

17 COM(2020)798/3

18 The GHG metric also needs to distinguish those GHG emissions that are already subjected to other climate policy measures from unregulated emissions.

manufacturing stage have already accrued at the time of the vehicle purchase decision. Manufacturers incorporate them in vehicle retail prices so they are highly salient and thus hardly subject to undervaluation by vehicle buyers.[19]

For all these reasons, **we advocate against including lifecycle emissions in the legislation on vehicles**.

3.3 Target path: annual targets

Up to now, new targets in regulating the environmental performance of motor vehicles have usually been set in roughly five-year intervals. This applies both to air pollutants and greenhouse gas emissions. In between these step changes, the targets remained constant. One might argue that this gives a certain relief to the industry as it digests one stage and prepares for the next. However, a manufacturer's fleet mix is not changed all at the same time. Environmental improvements are a part of the wider development process of new models of cars and come to the market when these models are ready. Those dates differ from one manufacturer to the next and across their different models, and the precise times are closely guarded commercial secrets. It would thus be natural to stretch the improvement of the fleet out over time and thus also to spread out the necessary investment. Otherwise, the industry is motivated to keep emission levels as high as permitted for as long as possible and to postpone bringing the required innovations to the market until the last moment. This effect has been seen e.g. with the levels of electrification going from 2019 to 2020, when the new limit value of 95g/km started to apply for 95% of the fleet and the market share of electric vehicles in the EU jumped from 3 percent in 2019 to 11 percent in January 2020[20].

What matters for climate protection are the cumulative emissions. Therefore, such a step-wise improvement results in foregone environmental benefits compared to a smoother pathway where the vehicles' specific emissions continue to decrease between target years. In that latter case the average emissions of the entire vehicle stock would be lower, and so would be the total CO_2 emissions from the transport sector.

For that reason, it could be considered applying new limit values not in a step-wise fashion but in a linear pathway that connects one key year to the next. The existing approach of a constant limit value could be kept until 2025 to allow the industry to prepare for the transition, but it could be applied from 2026 onwards. This would help to avoid a situation where the substantial electrification of the fleet would be postponed to the last possible moment and would only start one or two years before 2030.

In order not to constrain manufacturers' investment planning unduly, a schedule of yearly CO_2 targets could be accompanied by a new flexibility mechanism ("banking") that rewards overachievement and provides a safety buffer. If a manufacturer's average emissions are below its target value for a particular year, credits would be generated that could be used by the manufacturer to offset undercompliance in the following year, or to sell to another manufacturer for the same purpose.

3.4 Utility parameters

The current format of the legislation uses a limit value curve that allows higher emissions for vehicles with a higher value of the utility parameter. The utility parameter is set to be the mass of the vehicle. This is widely known to be a suboptimal choice, as described in more detail in the Annex. Therefore, the current utility parameter ought to be replaced by one that is more suited to the task, or possibly abandoned outright.

19 Whether these energy costs include all environmental costs is another issue that is, however, better addressed by other regulatory means than vehicle CO_2 standards. Disposal-related costs (or revenues) also occur in the future, but they do not justify much concern with regards to the undervaluation rationale as (a) their absolute magnitude is rather small and (b) they are often not borne by the consumer.

20 ICCT(2021)

However, changing the utility parameter may have distributional impacts on the manufacturers which would cause political resistance and thus, delay. It is not realistic to reopen this debate in the short time available until the proposal is supposed to be presented according to the Commission's time planning (June 2021). It is all the more important, then, to maintain the safeguard clause according to Article 14 of the Regulation which regularly adjusts the mass M_0 in the limit value curve. These adjustments prevent the actual average mass of the fleet as a whole from deviating too far from the value laid down in the Regulation.

Looking beyond the current revision, **the groundwork should be laid for switching or abandoning the utility parameter by including a review clause**, for example for a new proposal by 2023 as originally foreseen in the legislation. A new mechanism to assign manufacturer-specific targets should take effect no later than 2030. Further details are supplied in the Annex (section 7.2).

4 Level of stringency

4.1 Higher emission reductions and phase-out of combustion cars

For climate neutrality in 2050, a 50% reduction target for cars in 2030 as indicated in the Climate Target Plan is likely to be insufficient.

This statement is based on the study mentioned above which investigated how climate neutrality could be reached at the national level in Germany in 2050[21]. That study considers one member state, Germany, and for the whole economy in 2030 it assumes an interim greenhouse gas reduction target of 65% relative to 1990. This target was chosen in order to remain consistent with the tightening of the EU goal from 40% to 55% in 2030 as agreed by the European Council in December 2020. Both Germany and the EU are aiming at the same ultimate goal of climate neutrality in 2050.

As part of the necessary changes, the study finds that the emissions of newly registered cars need to be reduced by around 75% by 2030 as compared to the 2021 level on the national level. This is achieved by considering both a strong further emission reduction of combustion cars (by 28% over this time period) and an electrification rate that reaches a value of 78% in the year 2030 itself (for battery and plug-in electric vehicles together). If, instead, a lower improvement rate is assumed for combustion cars, the electrification rate would have to be even higher, though not very much so since the share of combustion cars is already small at that point. Likewise, the required electrification rate would have to rise if PHEV were found to contribute less to the reduction of emissions than assumed, as a result of lower shares of the electric drive mode. The scenario developed in the study envisages that from 2035 onwards, plug-in hybrid vehicles are no longer entering the market which is instead supplied entirely with battery-electric cars.

Quite apart from the precise situation in 2030, **a transition towards 100% zero-emitting vehicles is inevitable around 2035 at the latest in order to achieve a climate-neutral EU by 2050**. The reason for this is that the lifetime of passenger vehicles is around 14 years on average, while some have a longer lifetime. Therefore, a phase-out of combustion cars will have to take place around that time at the latest. A number of governments around the world have already announced their intention to phase out combustion-powered cars[22]. Several manufacturers are

21 KNDE(2020)

22 An overview has been provided by the ICCT: https://theicct.org/blog/staff/global-ice-phaseout-nov2020. The topic even has its own Wikipedia page: https://en.wikipedia.org/wiki/Phase-out_of_fossil_fuel_vehicles

also on record stating their expectation that there will be an end to combustion engines[23, 24].

The average emissions of cars in Germany tend to be higher than those at the EU level (in 2020, by 8.5% - see ICCT(2021) and ICCT(2021a)). However, regardless of their absolute values today, if they all have to come down to zero at a set date around or soon after 2030 then their relative improvement by 2030 will have to be of comparable magnitude. **We therefore suggest setting the emission performance target for 2030 at up to 75% below that of 2021** also at the EU level. In the impact assessment, it would be advisable to analyse even higher reduction values up to 100% which amounts to a complete phase-out of combustion-powered cars.

These high levels of emission reduction can only be achieved through rapid and wide-ranging electrification. A key requirement for that is the equally rapid build-up of an appropriate charging infrastructure. This must be addressed urgently by Member States and also at the EU level through the Alternative Fuels Infrastructure Directive.

4.2 Target path: the 2025 target

The shorter the time to a target year, the more difficult it is for the industry to make the necessary arrangements to reach the corresponding target. However, if the target 10 years from now is to be substantially tightened, it is reasonable to ask whether the target in 5 years' time can remain entirely unchanged, notably because already under today's regulation the average rate of improvement after 2025 is higher compared to that before, at 4.5 and 3.8 percentage points per year respectively.

Assuming that the 2025 target remains unchanged at 15%, a limit value of 50% in 2030 would require an annual rate of improvement of 7% after 2025 (see Table 1, top part). For higher targets in 2030 the improvement rate would be correspondingly higher.

For comparison, a constant rate of improvement from 2021 to 2030 would imply a limit value of about 17% in 2025 already for the existing 2030 target of 37,5%, and higher targets in 2030 would lead to correspondingly higher targets in 2025, as shown in the middle part of Table 1. Given the short period of time, this does not seem realistic especially for higher 2030 target values. However, it seems equally unrealistic to assume no change at all before 2025 and then a massive jump in the average improvement rate after 2025.

On balance, it seems sensible to assume that the rate of improvement increases over time as the industry progresses in the transition of power trains. The more ambitious the overall approach, the stronger it would be sensible to set the improvement rate after 2025 as compared to before. For illustration, Table 1 (bottom part) shows an intermediate approach where the annual improvement rate rises after 2025, but not as much as in the top part. In this case, a target of 75% in 2030 would be accompanied by a target of 28% in 2025, while for a 100% target in 2030 the value for 2025 would be 35%.

23 For example Volvo: https://www.ft.com/content/5c511e5d-404e-45f1-9057-96cc2f947ec9, GM: https://www.cnbc.com/2021/01/28/general-motors-plans-to-exclusively-offer-electric-vehicles-by-2035.html, and the supplier ZF: https://www.suedkurier.de/ueberregional/wirtschaft/klare-botschaft-aus-friedrichshafen-zf-chef-distanziert-sich-vom-verbrennungsmotor;art416,10719959

24 The only alternative to a phase-out of combustion engines would be the use of climate-neutral fuels. We consider this option unlikely because of the high cost of these fuels as well as the time required to develop the necessary fuel production infrastructure and its long required operating time. We also see this option as undesirable because it requires maintaining two technology pathways in parallel, and it diverts scarce low-carbon fuels away from applications where no alternative is available. We therefore also argue against the accounting of fuels in the car standards, as outlined in more detail below in chapter 6.

Table 1: Different approaches to the 2025 limit value as a function of the 2030 limit value.

Limit value in 2030			37,5%	50%	75%	80%	90%	100%
Existing	LV 2025		15%	15%	15%	15%	15%	15%
	Imprv./year[(a)]	2021-2025	3,8%	3,8%	3,8%	3,8%	3,8%	3,8%
		2025-2030	4,5%	7%	12%	13%	15%	17%
Linear	LV 2025		17%	22%	33%	36%	40%	44%
	Imprv./year[(a)]	2021-2025	4,2%	5,6%	8,3%	8,9%	10,0%	11,1%
		2025-2030	4,2%	5,6%	8,3%	8,9%	10,0%	11,1%
Intermediate	LV 2025			20%	28%	29%	32%	35%
	Imprv./year[(a)]	2021-2025		5%	7%	7,4%	8%	8,7%
		2025-2030		6%	9,4%	10,1%	11,6%	13%
	Ratio[(b)]		1,18	1,18	1,34	1,37	1,44	1,5

Agora Verkehrswende (own calculations)
(a) Percentage points per year, i.e. assuming a linear improvement path over time.
(b) This is the ratio of the annual improvement rates after and before 2025. For a 2030 limit value of 50%, the ratio is set at the same value as with today's regulation (a factor of 1.18). For a limit value of 100%, the ratio is chosen at 1.5, and the other values are interpolated. Numbers are rounded.

5 Handling the influence of electrification

5.1 Electrification and its effect on combustion cars

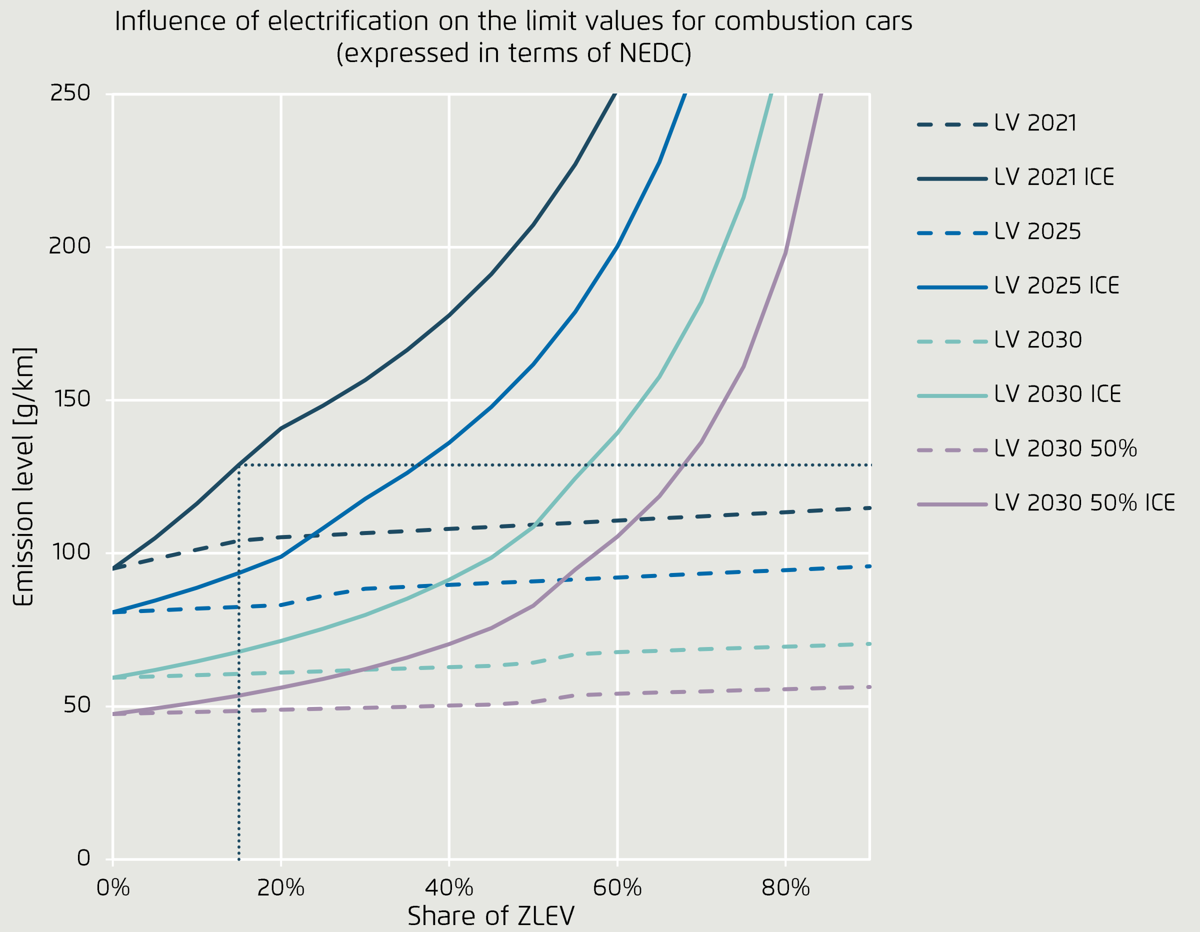
Once the market introduction of zero and low-emission vehicles (ZLEV) takes off in earnest, the rising share of these vehicles in manufacturers' fleets leads to a situation where the remaining internal combustion vehicles (ICEV) are subject to more and more relaxed allowable CO_2 emission levels. That is because the limit value must be met for all vehicles on average. If zero emission vehicles constitute a share x of the fleet, this implies that the combustion cars can emit $1/(1-x)$ times as much as the limit value[25]. As x rises, this factor quickly grows, until the emission levels of combustion cars are no longer constrained by the legislation[26]. This effect is illustrated in the following graph.

The black solid and dashed curves in Figure 1 refer to an example manufacturer in the year 2021. The emission values refer to the old NEDC test procedure because the limit value for 2020/2021 is expressed in this metric, and because the WLTP values will only become available after the end of 2021. However, the arguments made in the following are independent of the measurement method used to quantify the vehicle emissions.

25 In addition to this, the Regulation includes mechanisms that further relax the limit value, in the form of super-credits for 2020-2022 and the ZLEV factor from 2025.

26 A more detailed description of this effect has been given in https://www.agora-verkehrswende.de/en/blog/making-the-car-co2-standards-fit-for-the-electric-age/

Figure 1: The effect of electrification on the allowable emission level of combustion-powered cars.



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In this example the following parameter settings were used:

- The average mass of this (nonexistent) manufacturer is set at 1380kg which is close to the average mass M0 set in the legislation for the limit value curve. It can therefore be considered representative for the fleet as a whole.
- It has been assumed that electric vehicles weigh on average 500kg more than their conventional counterparts, and that plug-in hybrid vehicles weigh 277kg more.
- Plug-in hybrid electric vehicles (PHEV) constitute 40% of the ZLEVs.
- The emission level of PHEV has been assumed at 50g/km.

One might expect that the regulator can anticipate the described effect and can thus set the overall target in such a way that it still poses binding constraints on the emissions of combustion cars, based on assumptions regarding the uptake of electric vehicles. However, the required limit value would sensitively depend on the market shares of electric vehicles whose dynamics are hard to predict for the coming decade.

Because of the higher mass of ZLEVs, the fleet-wide limit value (the black dashed line) rises slightly with increasing electrification. This is because the higher mass of the electrified vehicles pushes up the average mass and thereby the limit value due to the sloping limit value curve. For the first 15% or so it rises at a steeper slope because of the super-credits[27]. However, both effects are dwarfed by the direct effect of the electrification on the combustion cars as described in the beginning of this section (the black solid line).

Looking ahead to the year 2025 (the blue curves), the dashed limit value line not only rises slightly due to the weight effect[28], but also shows a kink between about 20% and 30%. This is the effect of the ZLEV factor[29].

The current limit value for 2030 of 37,5% below the 2021 value is shown by the green curves, where the ZLEV factor shows its effect above 50%. Finally, a hypothetical new limit value of 50% below 2021 values, as referred to in the climate target plan, is indicated by the purple curves.

To sum up: **with rising electrification there is a risk that combustion cars will emit more in the future rather than less if no action is taken**, which runs counter to the intentions of the legislation. A possible remedy is suggested below in section 5.3.

5.2 The implications of electrification on energy consumption

Since the average emission level per car stays roughly the same with rising numbers of electric vehicles, the overall consumption of fuel also stays the same. However, a rising amount of electrical energy is consumed in addition by the electric vehicles[30], so the total amount of energy consumption goes up.

Since the energy cost savings of motorists play a key role in the impact assessment of the fleet standards, forgoing these savings would render them less beneficial. Therefore, there is a rationale for limiting the emissions of combustion cars also from the perspective of consumer protection. In addition, a rise in the overall energy consumption of road transport runs counter to the energy policy objective of increasing energy efficiency.

5.3 Supplementary limit values for combustion-powered cars

The rise in the allowable emissions of combustion cars is not a breach of the legislation – it is a consequence of the fact that only the average over all vehicles is subject to regulation. However, this is not an effect that was deliberately included in the design of the legislation. It would also constitute an unnecessary step backwards as the technical standard of combustion cars risks falling below what has already been achieved. This effect can be countered with supplementary limit values that apply only to ICEV and that act as a backstop to prevent this kind of backsliding.

An example is illustrated in Figure 1 where it is assumed that this manufacturer meets the limit value in 2021 with a 15% share of ZLEV. The resulting emission level for combustion cars is indicated by a

27 Discussed below in section 5.4.1. For the year 2021, the super-credit factor is 1.67. The effect on the limit value is capped at 7.5g/km.

28 Strictly speaking, as the mass goes up with increasing electrification, the average mass M0 in the limit value curve will be adjusted every two years in accordance with Article 14 of the Regulation. In the present example this is ignored for simplicity.

29 See discussion in section 5.4.2

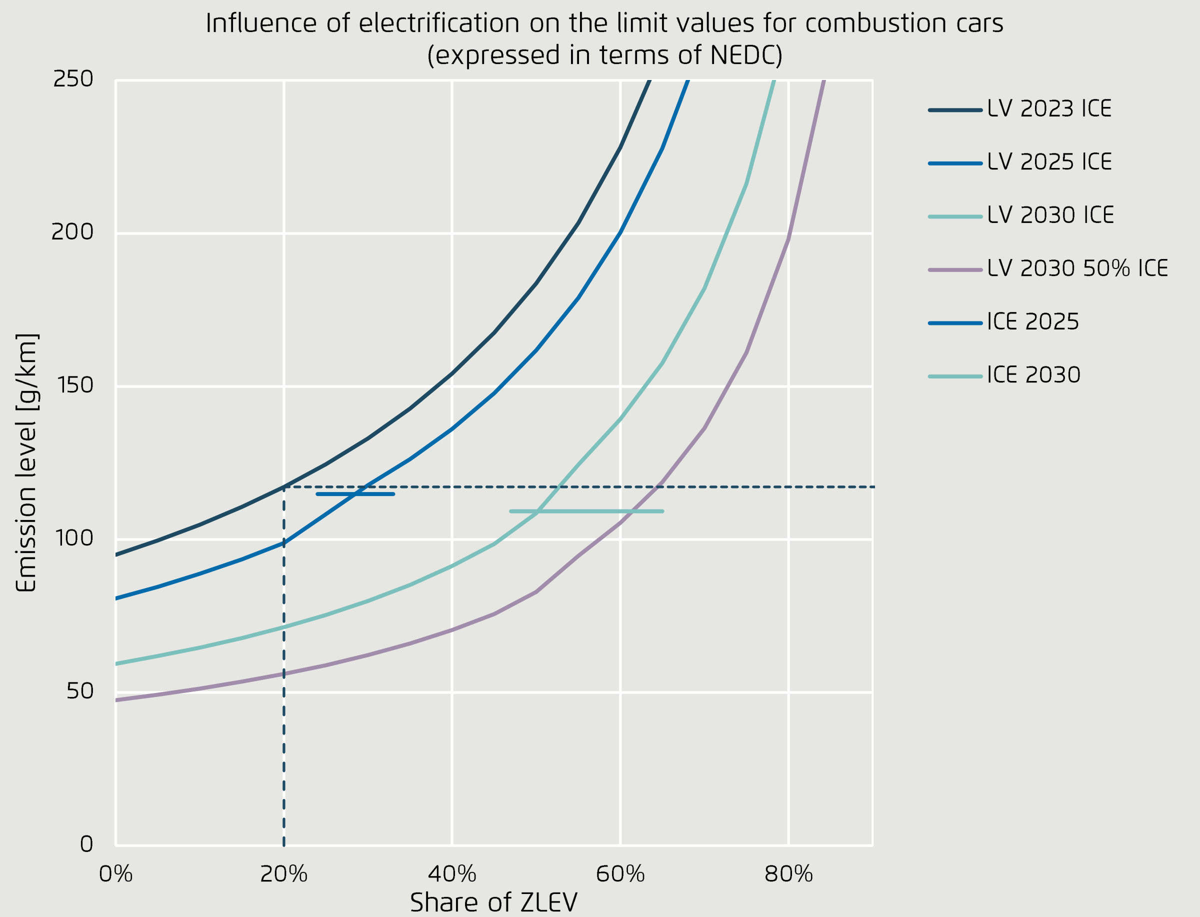
30 Ignoring complications caused by possible changes in the annual mileage or the influence of PHEVs whose real-world emissions and fuel consumption have been observed to be much higher than certified.

thin dotted horizontal black line. Assuming that the manufacturer does not improve the combustion cars further from here onwards and concentrates instead on electrifying their fleet, they would have to reach a ZLEV share of approximately 36% in 2025, and approximately 57% in 2030 under the limit value that is currently set for 2030. A tightening of the 2030 limit value to 50% (green line) would require an electrification rate of roughly 68% at that time. Thus, a backstop limit value for combustion cars does not have to interfere with the progress of electrification.

5.3.1 Stringency of supplementary limit values

As noted, combustion cars benefit from super-credits from 2020 to 2022, so their allowed emissions in 2021 as displayed in Figure 1 are even higher than otherwise. From 2023 onwards, this will no longer be the case so combustion cars will have to meet the values shown in Figure 2. Since this has to happen already under the existing legislation, it should be the starting point for determining the maximum allowable emission level for combustion cars. If we assume no further reduction in the emissions of combustion cars from that moment onwards, the values from

Figure 2: Same as Figure 1, but the black lines now refer to the year 2023 and thus, without applying the super-credit. A share of zero or low emission vehicles of 20% has been assumed for 2023.



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2023 would be the ones to use. For the present example this is indicated by the horizontal dotted black line in Figure 2.

However, it is likely that there are still a number of low-cost options left by that time to further improve the combustion cars, so it may be considered too conservative to maintain the emissions of these cars at the same level and not improve them at all.

The decision on the degree to which combustion cars should further reduce their emissions after 2023 depends on the cost curves for these vehicles. These will not be considered in the following. Instead, we ask whether this further improvement acts to slow down the rate of electrification because there is a trade-off: the higher the emission reduction that is achieved by combustion cars, the less electrification is needed to meet a given limit value. Consider again the example of the same hypothetical manufacturer, but this time with an assumed electrification rate of 20% in 2023. Assuming an improvement rate for combustion cars of 1% per year from then onwards results in the short blue horizontal line for 2025 in Figure 2, and the red horizontal line in 2030. If this behaviour is imposed, then the electrification rate in 2025 will have to be lower by just 1,5% in 2025, and by 3% in 2030 compared to a situation with no improvement of combustion cars[31]. This indicates that the considered amount of tightening of the requirements for combustion cars does not hinder progress in electrification.

Selecting the value of the improvement rate will have to be informed by an analysis of the remaining low-hanging fruits in improving combustion cars, and by a debate about how much effort the car makers should invest in a further improvement of the combustion cars as compared to the electrification of their fleets.

To conclude, **we suggest setting supplementary limit values for combustion cars based on their emission levels in 2023, with an additional improvement factor that should be set in view of the cost curves for the remaining technical options**.

5.3.2 Formats of supplementary limit values

There are different formats of setting a backstop limit value for combustion cars, such as:

- Grandfathering: manufacturer-specific supplementary limit value based on their 2023 average for combustion cars
- A supplementary limit value curve, obtained by
  - a regression line based on the combustion cars registered in 2023
  - parallel shifting of the overall limit value curve to match the average emissions of combustion cars in 2023
  - multiplying the overall limit value curve with a factor

Manufacturer-specific limit values based on their emissions at a certain time would have a distributional impact by rewarding early movers. Those who have already achieved strong electrification rates by 2023 would be granted comparatively more lenient backstop limit values for their combustion cars. On the other hand, those who have invested more to make their combustion cars more efficient while postponing the electrification would be held to more stringent standards for combustion cars during their later electrification phase, which could be perceived as unfair. A manufacturer-specific approach would also pose questions on how to deal with pools, especially if these are comprised of manufacturers with very different rates of electrification in 2023.

A limit value curve, on the other hand, would be influenced by a combination of the electrification efforts of all manufacturers. This would smear out

31 Always assuming that the emissions of combustion cars are as high as the legislation allows.

these effects and thus appear more attractive. Among the three options above, a regression line might be found to have a slope that is quite different from that of the overall limit value curve, risking distortions. A parallel shift would be harder on heavier cars and more lenient for lighter cars because it is equivalent to a multiplication with a factor followed by a rotation to make the curve flatter. That would be in line with the general motivation of reducing emissions which are higher for heavier cars. However, historically the slope of the limit value curve was the most contentious political point by far because it directly influences the competition between the manufacturers of heavier and lighter cars. The last option of simply multiplying with a factor is most directly related to past political compromises regarding the distribution of efforts among manufacturers. It would apply a single factor everywhere regardless of mass.

5.3.3 Plug-in hybrid vehicles and supplementary limit values

PHEVs require special consideration. On the one hand, they are combustion cars and therefore could be considered among the cars to which the supplementary limit values apply. On the other hand, they also offer the possibility of being driven in electric mode at least partially. This share of externally charged electric driving brings down their officially measured tailpipe CO_2 emissions. Their unqualified inclusion would thus reproduce the same type of situation that led us to propose supplementary standards in the first place: weakening the effective constraints that the supplementary limit values impose and thus allowing rising emissions for pure combustion cars. This effect is further amplified by the fact the current WLTP procedure ascribes unrealistically low emission values to PHEV, as discussed in section 5.5. Therefore, PHEVs as currently measured should not be counted among the combustion cars that would be subject to the supplementary limit value.
It should be noted that PHEVs are tested separately in two separate operating modes. The charge-depleting mode starts with a fully charged battery and depletes it in the course of the test, while in charge-sustaining mode the state of charge of the battery remains unchanged on balance and the propulsion energy is provided exclusively from the fuel tank. The two values are combined into a single effective fuel consumption and CO_2 emission level by using so-called utility factors. The more a vehicle is assumed to be driven in electric (charge-depleting) mode, the higher its assigned utility factor. The choice of methodology in setting the utility factors thus requires making assumptions about the way in which the vehicle is used in practice, which is the vulnerable point of the WLTP testing regime for PHEVs (see section 5.5).

While driving in charge-sustaining mode, a PHEV is operated like a hybrid vehicle without external charging which is a type of exclusively combustion-powered car. Therefore, it could be sensible to include the PHEVs in the scope of the supplementary limit value using exclusively their emission levels in charge-sustaining mode.

5.4 No further need for special ZLEV incentives

As ZLEVs begin to enter the mainstream, two special support mechanisms that were appropriate as long as these vehicles were a niche phenomenon become obsolete and counterproductive, as discussed in the following.

5.4.1 Super-credits

The so-called super-credits are a mechanism that rewards zero and low-emitting vehicles by allowing manufacturers to count each ZLEV as if it were more than one vehicle for the purpose of compliance, thereby relaxing the average limit value. This instrument has been used for limited periods of time, first when the legislation was first introduced (2012-2015) and then again at the transition to the current limit value from 2020. The respective multiplier is set at a value of 2 for 2020 and drops in annual steps until it reaches 1 in 2023. The total relaxing effect on the limit value is capped at 7.5g/km.

Super-credits obscure the legislative mechanism by introducing non-existent numbers of vehicles, which makes it more difficult to track compliance. They are an example of a class of regulatory devices that seek to support a secondary goal in a regulation by creating incentives that work through weakening the primary goal of that same regulation[32]. In the early years of introducing ZLEVs the resulting distortion was small. However, as the share of ZLEVs becomes more substantial, the impact on the allowed emissions of combustion cars is correspondingly larger as seen in the black solid line in Figure 1 which initially is noticeably steeper than otherwise.

Super-credits do not apply beyond 2022 under the current legislation. **This mechanism should not be reintroduced in future adjustments of the limit value.**

5.4.2 The ZLEV factor

From 2025 onwards a separate mechanism applies with the goal of supporting the market introduction of ZLEVs, the so-called ZLEV factor. If a manufacturer's share of low-emissions vehicles exceeds a threshold value, its overall CO_2 limit value is relaxed. Like super-credits, this mechanism effectively relaxes the overall stringency of the standards which permits a higher average emission level and higher energy consumption of the new vehicle fleet. Unlike super-credits, it only kicks in once a threshold value of ZLEVs is brought to the market. The impact of the ZLEV factor is capped at a maximum of a 5% increase in the limit value. Its effect is therefore small compared to the direct impact of electrification as seen in Figure 1.

It is uncertain whether the ZLEV factor – as well as the current super credits – will actually trigger a larger electric vehicle market share[33]. It is well conceivable that the opposite may happen: that is, the ZLEV factor could lead to fewer rather than more EVs in the new vehicle fleet, while still adversely affecting the overall stringency level of the regulation. Manufacturers could stop at lower electrification levels as a smaller number of electric vehicles suffices to substantially reduce the regulatory pressure to improve the emissions performance of combustion cars. In the interest of environmental integrity as well as transparency and simplicity, **a strong case can be made for the ZLEV factor to be dropped**.

5.5 The real-world emissions of plug-in hybrid vehicles

From an energy efficiency perspective, most plug-in hybrid vehicles (PHEVs) currently on the market tend to be neither good electric vehicles nor good combustion vehicles, because they carry two full power trains and are therefore heavier and inherently less energy efficient than any of the two alternatives on their own. However, they have the advantage of removing range constraints and the associated range anxiety when driving electrically, and when used in an optimal manner, they can reduce the CO_2 emissions of cars considerably. "Optimal" in this context means that the battery is being externally charged as often as possible so the vehicle can be operated in electric mode for the largest possible part.

The share of electric driving is expressed in the form of a utility factor[34]. This factor depends on the electrical range of the vehicle: the longer that range, the higher the proportion of electric driving that is theoretically possible during the vehicle's operation. But the factor also depends on the user behaviour. The maximum electrical range can only be realized if the battery is being consistently charged externally. The experience gathered so far[35] suggests that in practice, PHEVs are not being used optimally in this sense at all and that their CO_2-reducing potential is therefore

32 Another example would be the multipliers for various types of renewable road fuel in the Renewable Energy Directive (RED II), Directive (EU) 2018/2001.

33 See Elmer (2016), pp. 343.

34 Defined as the proportion of the distance over which the vehicle is operated in charge-depleting mode (i.e. electrically), compared to the overall distance driven

35 ICCT(2020)

not realized. In other words, the utility factor observed in real driving does not correspond to the one used in the EU type approval test[36]. Consequently, instead of the very favourable CO_2 type approval values typically found for PHEVs, their real emission values are much higher. On average, the real-world fuel consumption is 2-4 times higher than provided by the values under the New European Drive Cycle (NEDC) and the World Light-duty Test Procedure (WLTP), depending on the model, country and user group. This difference is due to three shortcomings in both test procedures:

- they assume daily charging which is not the case in reality;
- they apply higher shares of electric and charge-depleting driving modes than observed in reality;
- they are less demanding than in real world usage.

The test procedure currently in force thus gives the wrong incentives by applying unrealistically favourable assumptions on the way these vehicles are being used. The WLTP Regulation itself notes the inadequacy of the utility factor that is being used, since it is based on the driving characteristics of conventional vehicles[37]. The remedy is obvious and must be initiated swiftly: utility factors must be chosen such that they correspond to the real use of these vehicles on average.

Because of the excessive emissions of PHEVs in practice and their importance in the fleet mixes coming to the market, this adaptation cannot wait for a full EU-wide verification programme which may take several years. There are already emission values and utility factors for PHEVs available from recent studies. ICCT(2020) finds that the real-world utility factors are about half of those in the test procedures. Some scatter is found across different countries, but these values are likely to be much closer to reality than the values currently being used. We therefore suggest **amending the type approval procedure for PHEVs by using 50% of the utility factors from the official test procedures on an interim basis**, and to amend the procedure again once a more systematic data set has been established.

6 Accounting for fuels in the limit values

Some actors promote a crediting system through which it would be possible to declare a combustion-powered vehicle as a zero-emission vehicle if it is demonstrated that the manufacturer has purchased an amount of zero-emission fuel that is equal to the expected lifetime fuel consumption of that vehicle. This idea is also reflected in the list of topics that the Commission has to cover in the review in accordance with Article 15(2) of the Regulation on the CO_2 performance of cars and vans[38]. **We strongly advocate against this option**, for a multitude of reasons as follows.

1. **Distraction from the technical improvement of vehicles**. The limit values have been the most effective instrument to improve the efficiency of road vehicles and to realise the transition towards electric propulsion systems that is widely seen as necessary. The threat of high penalty payments motivates manufacturers to reduce the CO_2 emission levels of their vehicles and to bring these vehicles to market. Accounting for fuels would instead open the possibility for manufacturers to buy in certain fuels rather than technically improving their vehicles, without

36 The World Light-duty Test Procedure (WLTP) as defined in Regulation (EU) 2017/1151.

37 The utility factors are defined in Regulation (EU) 2107/1151, Annex XXI, Sub-Annex 8, Appendix 5. The first paragraph in this Appendix states: "The database used to calculate the Utility Factors in paragraph 2. was predominantly based on the use characteristics (e.g. utilization, daily driven distance, shares of different vehicle classes) of conventional vehicles. It will be necessary to re-evaluate UF and charging frequencies by a customer study once a significant number of OVC-HEV vehicles are in use in the European market."

38 Strictly speaking, the Commission has to consider "the potential contribution of the use of synthetic and advanced alternative fuels produced with renewable energy to emissions reductions". The article does not say how this contribution has to come about, so the link to the car performance standards is an interpretation.

contributing to climate protection. To the extent that this happens, the legislation would lose its effect.

2. **Loss of credibility and transparency**. The credibility of legislation on the environmental impacts of road vehicles has been strained in the past, due to both the diesel scandal and the ever-growing deviation of real-world fuel consumption and CO_2 emissions from the laboratory values. Accounting for fuels would result in a situation where vehicles that are operated with conventional fuels are being declared as zero emission vehicles via certificate. Even if this can be argued on a theoretical basis, it must appear absurd to outsiders and in any event will be perceived as a dodge. This should be expected especially if such vehicles were to benefit from the sizeable subsidies and tax breaks available for zero emission vehicles. In addition, the rules on the CO_2 emissions and renewable energy in transport, already hard to understand, would become even more obscure.
3. **Lack of availability**. At first sight, it would seem advantageous to introduce low-carbon fuels in order to supply the existing fleet, since combustion-powered cars will continue to form the majority of the fleet for some time. However, the necessary production plants to supply this fleet with synthetic fuels do not exist at present and will take a long time to ramp up. A process of R&D followed by the establishment of pilot plants is required before the first large-scale plant can go onstream. The German National Platform on the future of Mobility (NPM), which includes all industrial stakeholders, has recently shown[39] that the first such plants can be expected to enter production around 2028-2030. That is far too late to make a noticeable difference, as the electrification of the fleet will be in full swing around that time. Such plants would produce an energy of 4 PJ per year each (100,000 tonnes). Even if multiple plants are being built, this is dwarfed by the amount of energy consumed by road transport in the EU which in 2018 amounted to 11200 PJ (268 million tonnes of oil equivalent)[40].
4. **Diversion of fuels from sectors without alternative**. Including any kind of alternative fuel in the CO_2 target for light-duty vehicles would divert the limited available volumes of sustainable biofuels and synthetic fuels away from sectors that are more difficult to decarbonize or impossible to electrify, such as aviation or the manufacture of base materials.
5. **Loss of effectiveness by mixing separate areas of regulation**. The CO_2 standards regulate the technical characteristics of road vehicles whereas the legislation on energy regulates the properties of energy carriers in transport. To the extent that an accounting system as described is introduced, climate-related improvements would no longer take place in both sectors in parallel but in just one of them. That would reduce the effectiveness of climate policy in transport overall. The interaction between the two areas can also lead to a rise in the costs of climate protection without any additional benefit by creating a new and potentially expensive market for alternative fuels.
6. **Increased social costs**. The existing CO_2 standards lead to lower fuel costs over the lifetime of the vehicles which has been shown not only to counteract the increase in the costs of making the vehicles but even to overcompensate it[41]. From a social cost perspective, the costs of CO_2 reduction are thus negative, and the same applies to vehicle owners. Conversely, accounting for synthetic fuels would strongly increase these costs, both from the perspective of vehicle owners and of the economy as a whole, because the vehicle efficiency would not improve while fuels would become more expensive. This is because synthetic fuels are expected to be expensive to produce for the foreseeable future[42].
7. **Interference with national obligations to reduce emissions**. If a vehicle manufacturer purchases a certain amount of renewable fuel for accounting purposes in connection with a vehicle

39 NPM(2020), especially Figure 4.
40 EU Transport in Figures (2020)
41 SWD(2017)650, section 6.3.2.2.1.2: TCO-15 years (vehicle lifetime)
42 Based on Prognos(2019), the cost of liquid synthetic fuels for consumers are expected to be around 3.50 € per litre in 2030 and still around 2.80 € by 2050 before taxes. An earlier study found costs in the order of 1-2 € for 2030 and 1-1.40 € for 2050, see Frontier Economics (2018). Sizeable error bars are attached in both studies.

that is registered in one member state, the fuel would very likely originate in a different country. Accordingly, the CO_2 reduction associated with the production of the fuel would be ascribed to that second country. Such a vehicle would thus not contribute to achieving the member state's obligation under the Effort Sharing Regulation. For a member state such as Germany, this would in all likelihood hinder the achievement of the national climate target in the transport sector as alternative fuels are cheaper to produce in other member states.

8. **Danger of further undesirable effects as regards fuels**. The accounting of fuels in the vehicle legislation is often portrayed as an instrument for bringing expensive synthetic fuels to the market. However, the most cost-effective of these would be conventional biofuels which should not be extended further in view of sustainability concerns. If these were to be included, the accounting scheme would counteract these sustainability goals. For example, a methodological study commissioned by the German economics ministry[43] includes in the scheme all the types of fuels that are defined in the Renewable Energy Directive (RED II). Even if a proposal from the Commission were to be limited to synthetic fuels, the scope may be extended to other fuels during the co-decision process.

43 Frontier Economics (2020)

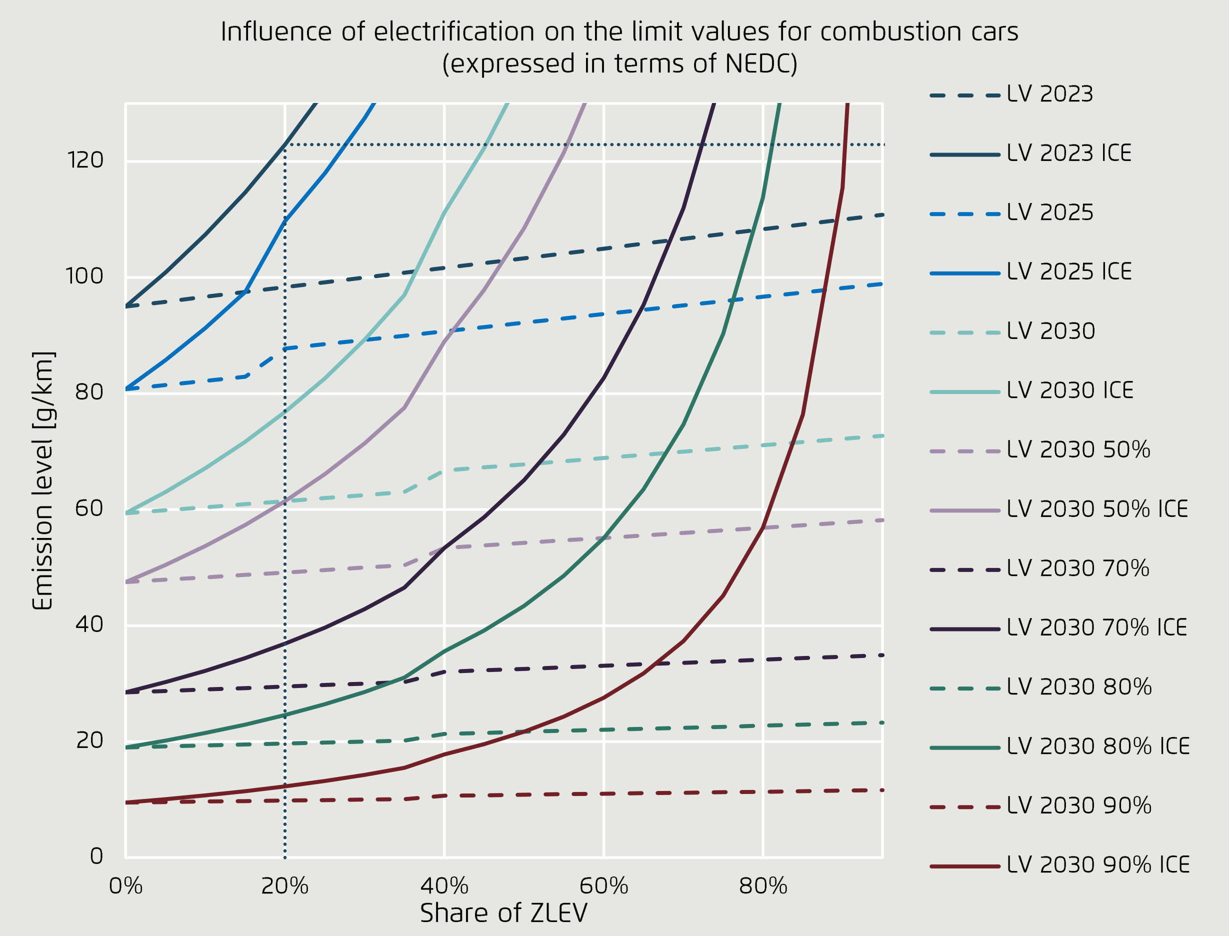
7 Annex

7.1 Further details on the effects of electrification

Section 5.1 illustrates the effect of electrification on the allowed emission levels for combustion cars. In Figure 1 we are looking at those fleet-wide limit values that are already set in the legislation for the coming years, and also at a value of 50% below 2021 as envisaged in the Climate Target Plan. However, as argued in section 4.1, our analysis suggests that a stronger reduction is needed by 2030. This is depicted in Figure 3.

Details will vary according to the assumptions made about the allowed emission levels for combustion cars, the share of PHEV among the ZLEVs etc. However, the general tendency is that for the more stringent levels of emission reduction, the amount of electrification in 2030 is not very different from the percentage reduction of the 2030 limit value compared to 2021.

Figure 3: A wider range of limit values in the year 2030, and their implications for combustion cars. In this example the electrification is achieved entirely with battery-electric vehicles for all cases shown, because the very strong emission reductions would not be possible with plug-in vehicles.



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7.2 Further details on utility parameters

7.2.1 Historical roots

The current format of the legislation goes back to political guidelines that were drawn up in 2007. They stipulated[44] that "*the legislative framework implementing the average new car fleet target will be designed so as to ensure competitively neutral and socially equitable and sustainable reduction targets which are equitable to the diversity of the European automobile manufacturers and avoid any unjustified distortion of competition between automobile manufacturers.*" The main concern was thus that all manufacturers should be able to live under the new regulatory regime. This goal was achieved in two ways: by only regulating the average emissions of a manufacturer's newly registered fleet in a calendar year rather than each car individually, and by allowing higher emissions for heavier cars[45].

The former feature is being justified by the fact that what matters for the climate is the total amount of emissions, not those of each individual car. For each cohort of new cars entering the market in a year, its total lifetime emissions are equal to the average lifetime emissions per car[46] multiplied with the number of cars.

These political guidelines rule out an approach that forces a general downsizing and downrating of cars in terms of size, power and speed, even though that would be the most obvious way of reducing the emissions. That is not only because of the obvious political sensitivity, but also because the manufacturers are positioned differently on the market: a general limitation of performance-related vehicle attributes would hit some more than others. Instead, the aim has been to ensure that the manufacturers of bigger, heavier and more powerful cars should be equally able to comply with the legislation.

This approach has been justified by the finding that cars that provide higher utility tend to be bigger. "Utility" was interpreted in this context purely in terms of transport services and thus related to the number of people and the amount of luggage that a vehicle can carry. That is not what would be considered as utility in a standard economic approach, which would encompass any features that people are willing to spend money on.

The idea was thus that higher emission values should be granted to cars with higher utility in the sense described. That is why the legislation makes use of a so-called utility parameter[47] that expresses the utility or that should at least correlate with it. The limit value is thus formulated in the form of a limit value curve such that the maximum CO_2 value is a function of the utility parameter, in the form of a straight line with a positive slope (Figure 4).

The limit value at the fleet average of the utility parameter is equal to the overall target value, thereby ensuring that the EU fleet as a whole meets the target even if the individual manufacturers are subject to different limit values according to their average utility values. This mechanism only works as long as the real average value of the utility parameter does not deviate from the one used for defining the curve.

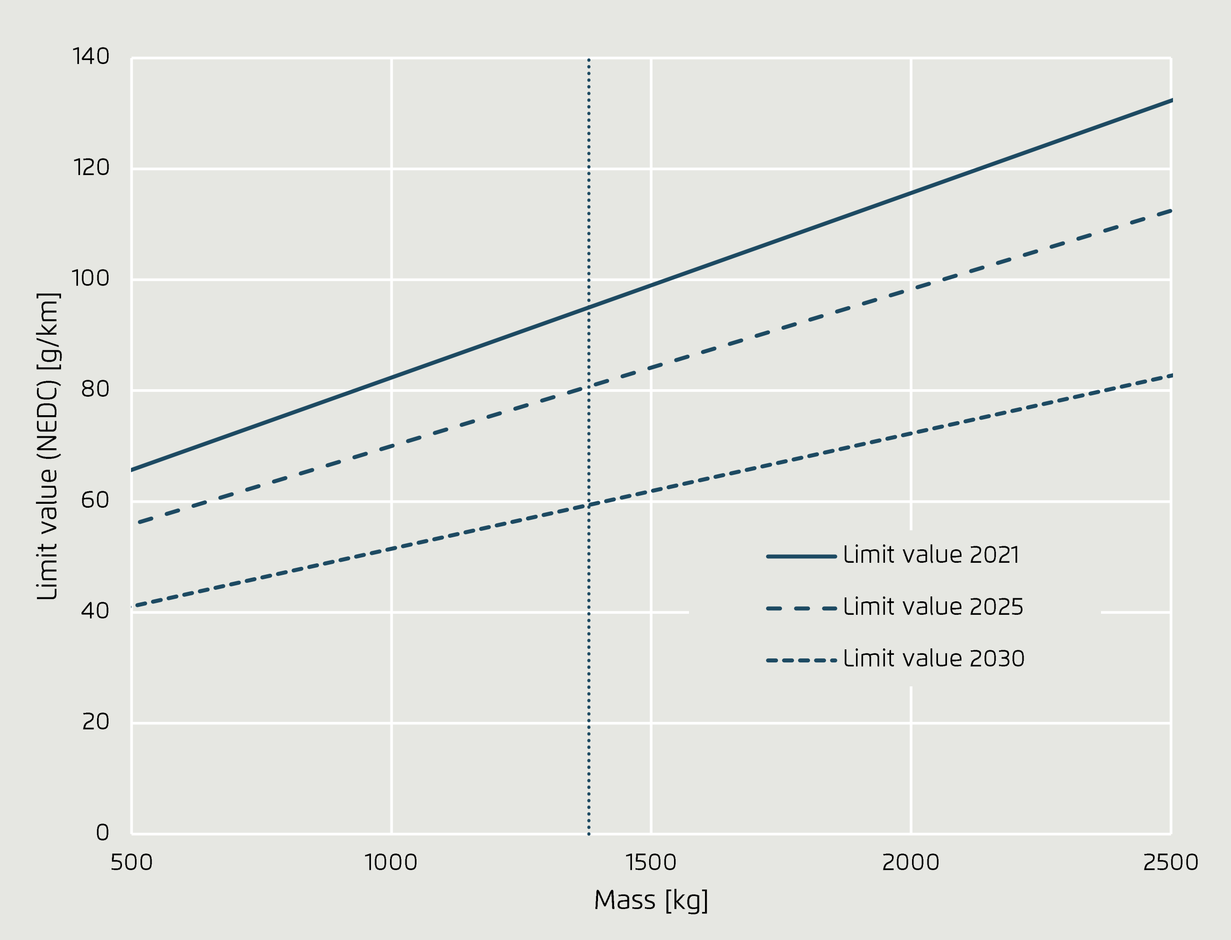
44 COM(2007)17, COM(2007)22

45 For those manufacturers whose emissions were off the map, the instrument of pooling was introduced, as well as special provisions for small-volume and niche manufacturers.

46 It should be noted that the average lifetime emissions (total tonnes of CO_2 per car) are a different concept from what is being regulated, which is the average of the specific emissions (i.e. the grams of CO_2 per kilometre for each car). These two only lead to the same result if all cars drive the same distance on average. But larger and thus higher-emitting cars tend to drive longer distances so the legislation is more advantageous for them by underestimating their contribution to the total CO_2 emissions. This also implies that making the limit value curve flatter and thereby more demanding on larger cars results in lower real emissions even as the fleet average is kept the same.

47 Not to be confused with the utility factor in the WLTP testing of plug-in hybrid vehicles (see section 5.5)

Figure 4: Limit value curves as currently defined in the Regulation. The dotted vertical line represents M0 (currently set at about 1380kg).



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In the sense laid out above, a good utility parameter for the purpose of regulating emissions would consist of a combined measure of the number of seats and the trunk space[48]. However, at the time when the legislation was first introduced the necessary data for this kind of metric was missing. The only data then available that correlated with the utility were the mass of the vehicles and the projected ground area[49]. The ground area was rejected because it was considered too easy to manipulate[50]. This left mass which was therefore used to formulate the limit value curve.

7.2.2 Quality criteria for utility parameters

From an economic viewpoint, the use of a utility parameter to assign manufacturer-specific emissions targets should help to minimize the overall costs of achieving the fleet-wide emissions target. This involves equalizing the overall marginal abatement

48 Allowing for complications such as the size of seats, foldable back seats and fold-up seats in trunks that are smaller and less comfortable or useable.

49 More precisely, the circumscribing rectangle of the projected ground area, i.e. length times width.

50 The front and rear ends of a car consist of plastic bumpers and it would be cheap to make them longer, thus gaining a higher ground area and a correspondingly higher limit value without any technical improvement.

costs across different manufacturers and vehicle types. By conditioning manufacturers' targets on their average vehicle mass, differences in their vehicles' abatement costs should be taken into account. At the same time, the utility parameter should not distort the manufacturers' abatement decisions. In particular, tapping cost-effective emission reduction options should not be disincentivized as this will increase the overall compliance costs.

Therefore, a well-suited utility parameter is characterized by being (a) a good empirical indicator for a vehicle's (marginal) abatement costs and (b) of minor importance as an abatement option.[51] The latter applies to vehicle attributes that have a relatively weak direct *physical* impact on the vehicle's emissions and are costly to adjust.[52] With regard to the latter, the use of vehicle mass as utility parameter has always been criticized because mass reductions as a viable and often cost-effective mitigation option are disincentivized; furthermore, mass-based standards go along with increased traffic safety risks.

7.2.3 Mass versus footprint

Given that one of the most obvious ways of reducing a car's emissions is to make it lighter, the choice of mass as the utility parameter was criticized for giving the wrong incentives. By expressing the limit values as a rising function of mass, reducing a car's mass is penalised as it leads to a lower limit value. Conversely, making a car heavier – which is the opposite of what is required – is being rewarded by a less stringent limit value.

The legislation contains a safeguard to prevent this effect from getting out of hand. The average value M_0 in the limit value curve is adjusted every two years in view of the observed mass, in order to prevent the fleet from drifting too far away from this value[53].

Aware of the problems related to the use of mass, the legislation contains a provision to prepare the ground for a future revision, by requiring that the footprint[54] of vehicles be reported as part of the monitoring. The necessary data is therefore now available to re-formulate the limit value curve as a function of footprint[55]. However, this was not done in the two revisions that have taken place in the meantime.

While the footprint in itself has little to do with the usefulness of a car, it does correlate with the utility as discussed above, but one key advantage for the purpose of legislation is that it is considered harder to manipulate. That is because changing the footprint of a vehicle means moving the position of the wheels which would require a complete redesign of the vehicle, and the placement of the wheels is linked to issues such as driving stability, handling, and the visual appearance of the car, all of which are important market-related parameters. The footprint is also more robust in terms of cost-increasing distortions as well as more suitable with regard to traffic safety concerns[56].

One of the criteria for a good utility parameter should be that a manufacturer can adapt a car towards lower emissions while maintaining the value of the utility parameter. The footprint offers a larger "utility-

51 Elmer (2016), pp.245-246.
52 A frequent misunderstanding is that good utility parameters show a strong physical correlation with the specific CO_2 emissions. The opposite is true: the better the physical correlation, the less useful the utility parameter for the purpose of legislation. Instead, there should be the possibility of maintaining the same utility while reducing the emissions. A certain degree of scatter around the trend line is thus a sign that the emissions can be reduced while keeping the utility of the vehicle unchanged.
53 In this case the limit value curve is adjusted by shifting it to the right, which is the same as shifting it downwards. Such an adjustment took place recently for light commercial vehicles for which the mass M0 was adjusted from 1766,4 kg to 1825,23 kg from 2021 (see C(2020) 5606). This means that vans have become heavier by almost 60kg over the last years. Given the slope of the limit value curve of 0,096, this implies a tightening of the limit value by 5,8g/km for any given vehicle mass.
54 Footprint means the product of the track width and the wheel base (the distance between the front and rear axles). In other words, it is the area of the rectangle circumscribing the points where the car touches the ground.
55 This approach is used in the U.S. for fuel economy and CO_2 regulations for light-duty vehicles.
56 Elmer (2016), pp. 252.

neutral" potential for emission reductions than vehicle mass. For example, the footprint of a vehicle is unaffected by its height. A higher vehicle has higher CO_2 emissions, other things being equal[57]. Hence, one result of using these utility parameters would be a disincentive to sell SUVs which are higher than ordinary cars. The existing utility parameter of mass tends to reward the introduction of heavy SUVs because their higher mass leads to higher limit values.

It should be investigated, however, how the wheels are placed in electric vehicles which may have higher degrees of freedom in positioning the components of the power train, and which may allow bringing entirely new vehicle architectures to the market. By placing the wheels nearer the corners of the vehicle, the average footprint of a manufacturer's fleet can be made to increase and thus also its permitted CO_2 value. The same caveat would apply for a regulation of energy efficiency if it is based on the same utility parameter. Thus, the perceived resistance against gaming that is ascribed to footprint should not be taken for granted as manufacturers electrify their fleets.

7.2.4 Utility parameters for an electrifying vehicle fleet

Taking account of the rapidly progressing electrification of the car fleet, elsewhere in this report we advocate for changing the scope of the legislation from the tailpipe CO_2 emissions to the specific energy consumption. Electrification not only affects the choice of the appropriate metric for vehicle standards (i.e., tailpipe CO_2 emissions versus energy consumption), but it also necessitates a thorough re-assessment of the rules to assign manufacturer-specific fuel economy targets. In view of the wide variety of electric vehicles and their energy consumption, it should be investigated whether such regulation of the energy efficiency of electric vehicles should be made dependent on a utility parameter similar to the format used for combustion-based cars.
On the one hand, the direct impact of vehicle mass on fuel economy declines for electric vehicles because they can (at least partially) recuperate the energy used for overcoming inertia and gradient resistance which increase with vehicle mass. Hence, the relative importance of mass reductions as a way of reducing the specific energy consumption decreases, mitigating the distortionary effect of mass-based standards.
On the other hand, the adequacy of mass as an indicator for a manufacturer's (marginal) abatement costs diminishes as the electrification of the drivetrain normally corresponds to a gain in vehicle mass, with other vehicle attributes unchanged. Thus, a manufacturer's average vehicle mass – and consequently its emissions target – increasingly represents the degree of electrification of the fleet rather than the vehicle size, which is an essential marginal abatement cost determinant. The diminished quality of vehicle mass as a proxy for the abatement cost may considerably harm the cost-effectiveness of this regulatory approach. Furthermore, differences among the manufacturers in their rates of progress in electrification can lead to widely variable abatement requirements and compliance costs, raising distributional controversies.

All taken together, mass is a poor choice for the utility parameter of an electrifying fleet. Weiss et al. (2020) suggest instead that the battery capacity would be a candidate for a suitable utility parameter. Yet, an even better utility parameter might be the range. Generally, it appears that attribute-based standards (i.e., standards using a utility parameter) tend to be less efficient for an electrifying fleet because it becomes more difficult to tailor an appropriate limit value function. This requires further study, as these aspects have not attracted much scientific interest so far.

57 Because of the higher air resistance and the increased mass of a larger car body overall.

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Agora Verkehrswende
Anna-Louisa-Karsch-Straße 2 | D-10178 Berlin
P +49. (0) 30. 7001435-000
F +49. (0) 30. 7001435-129
www.agora-verkehrswende.de
info@agora-verkehrswende.de

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