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BRIEFING

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Adjusting for vehicle mass and size in European post-2020 CO_2 targets for passenger cars

The European Union (EU) introduced its first mandatory carbon dioxide (CO_2) standards for passenger cars in 2009, after approximately 10 years of insufficient progress under voluntary industry self-regulation. With the mandatory standard, average CO_2 emissions declined steeply (Figure 1). A second standard followed in 2014, requiring manufacturers to reduce average distance-specific CO_2 emissions to 95 grams per kilometer (g/km) by 2021. A third round of standards is now in the works. The European Commission (EC) published a proposal in November 2017 suggesting a 15% reduction in CO_2 values from 2021 to 2025 and a 30% reduction from 2021 to 2030.[1]

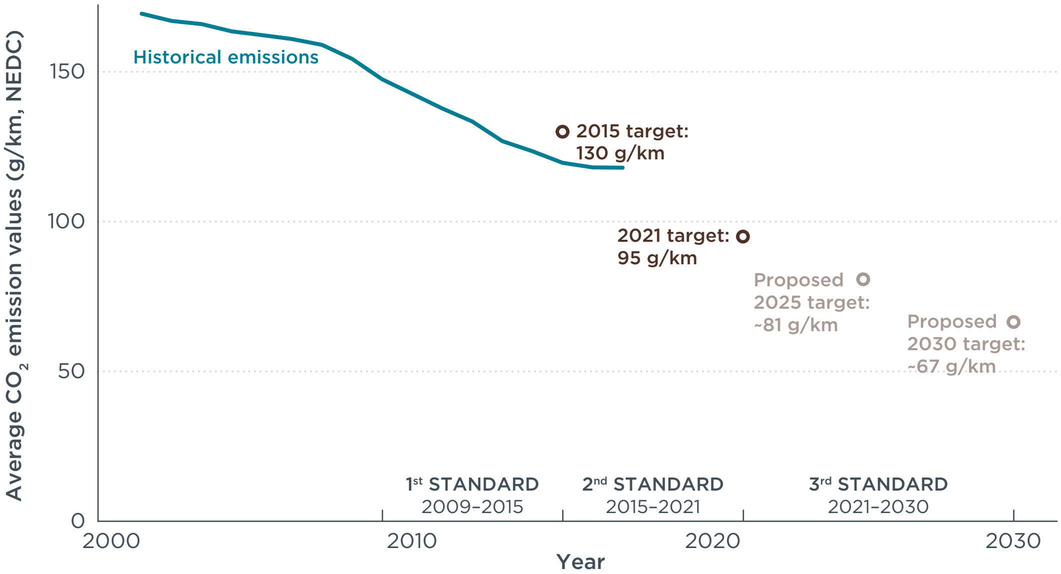

Figure 1. Average historical CO_2 emission values and adopted and proposed CO_2 standards for new passenger cars in the EU. All CO_2 values refer to New European Driving Cycle (NEDC) measurements.

1 Jan Dornoff et al., *The European Commission Regulatory Proposal for Post-2020 CO_2 Targets for Cars and Vans* (ICCT: Berlin, 2018), https://www.theicct.org/publications/ec-proposal-post-2020-co2-targets-briefing-20180109.

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Under all European CO_2 standards adopted and proposed, individual manufacturer targets are adjusted by the average mass of the manufacturer's fleet. The heavier the fleet, the higher the CO_2 emissions target, and vice versa. This so-called limit value curve, using mass as the utility parameter, was built into the CO_2 standards to maintain diversity in the vehicle market and to account for varying consumer needs.[2]

When mandatory CO_2 standards first came under discussion, a key argument for using mass as the utility parameter was data availability: mass data were readily available for all new vehicles in the market. However, with the introduction of the first CO_2 standard, the EC was required to systematically collect data on alternative utility parameters and to evaluate the possibility of adopting a different one, specifically vehicle footprint. Vehicle footprint, a measure of the size of a vehicle, is the utility parameter used in greenhouse-gas vehicle standards in the United States.[3] The second EU CO_2 standard, introduced in 2014, reiterated that a change to vehicle footprint should be considered in future reviews of the regulation.[4]

This briefing summarizes the implications of the current mass-based CO_2 targets in the EU and outlines three alternative regulatory options:

» Removing the utility parameter altogether

» Using vehicle footprint instead of mass as the utility parameter

» Keeping the mass utility parameter, but reducing its impact on manufacturers' CO_2 targets

In the interest of brevity, the briefing focuses on passenger cars (M1 vehicles), but similar concerns apply to light commercial vehicles (N1 vehicles, also referred to as "vans").

IMPLICATIONS OF USING MASS AS THE UTILITY PARAMETER

While a utility parameter was introduced into the regulation for the practical purpose of maintaining diversity in the vehicle market and accounting for varying consumer needs, it was at the same time a political compromise intended to protect the competitive positions of European automakers. German manufacturers of premium brands could continue selling larger, heavier cars with comparatively high CO_2 emissions, while their French and Italian competitors continued to sell smaller and lighter vehicles with lower CO_2 values. In practice, targets could differ by as much as 11 g/km in 2021. Figure 2 shows that, at the current average vehicle mass, Fiat Chrysler Automobiles (FCA) would have to meet a 91 g/km target in 2021 while Daimler would have to meet a 102 g/km CO_2 target.

2 Regulation (EC) No 443/2009, Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 Setting Emission Performance Standards for New Passenger Cars as Part of the Community's Integrated Approach to Reduce CO_2 Emissions from Light-Duty Vehicles, April 23, 2009, http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02009R0443-20130508&from=EN.

3 Peter Mock, *Evaluation of parameter-based vehicle emission targets in the EU* (ICCT: Washington, DC, 2011), https://www.theicct.org/publications/evaluation-parameter-based-vehicle-emissions-targets-eu

4 Regulation (EC) No 333/2014, Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars, March 11, 2014, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.103.01.0015.01.ENG

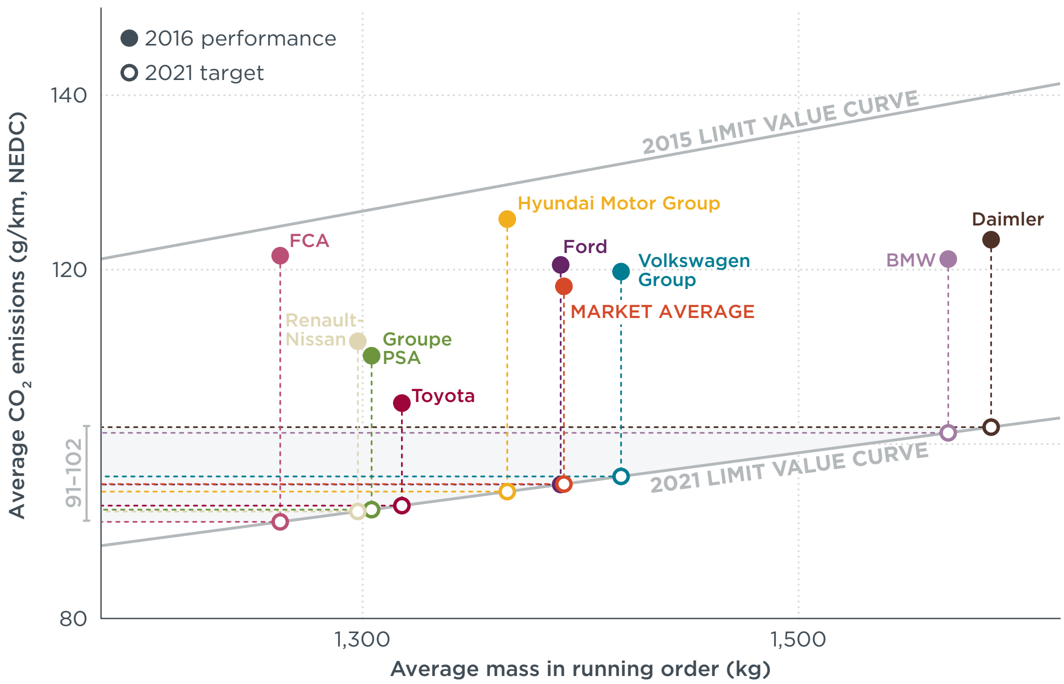

Figure 2. Average CO_2 emission values and vehicle mass of major manufacturer groups in 2016.[5] Hypothetical 2021 targets are based on average 2016 mass. Limit value curve for 2015 included for reference.

A major drawback of the mass-based limit value curve is that it disincentivizes vehicle mass reductions, so-called lightweighting. This is because under a mass-based limit value curve, part of the CO_2 reduction from lightweighting is offset by a more stringent CO_2 target (see Figure 6 for an illustration). Disincentivizing lightweighting is problematic because the mass of a vehicle and its energy consumption are directly linked, thus reducing mass is itself an important engineering option for reducing energy consumption and CO_2 emissions. The mass utility factor therefore limits the range of options for reducing CO_2, which results in smaller CO_2 reductions and higher compliance costs for manufacturers. For example, the cost of reaching a CO_2 reduction target of 15% by 2025, excluding mass reduction as a compliance measure, is about 400 euros higher than when including mass reduction (see Figure 3).[6] The EC, too, came to the conclusion that the compliance cost for an average passenger car in 2025 would be higher under a mass utility parameter than under a footprint utility parameter.[7] However, according to the EC figures, the savings for an average manufacturer would only be about 50 euros per vehicle, because the EC decided to use higher cost estimates provided directly by vehicle manufacturers instead of following the original recommendations of its consultants for lower lightweighting costs.[8]

5 Manufacturer groups are intended to mirror ownership structures in the automotive industry and may not reflect manufacturer pools used in the context of the CO_2 standards.

6 Dan Meszler et al., CO_2 reduction technologies for the European car and van fleet: Impact of mass reduction discounting on compliance costs for future EU CO_2 standards (ICCT: Washington, DC, 2017), https://www.theicct.org/sites/default/files/publications/CO2-reduction-technologies_white%20paper_10102017_vF.pdf

7 European Commission, Commission staff working document – impact assessment, (European Commission, 11 November 2017, SWD(2017)650 final), https://ec.europa.eu/clima/policies/transport/vehicles/proposal_en#tab-0-2

8 "[F]or the measure "Medium weight reduction (20% from the whole vehicle)" the CO_2 improvement was reduced by 4 percentage points . . . and its costs were doubled . . . , the measure "Strong weight reduction (30% from the whole vehicle)" was eliminated . . ." See J. Krause et al., "Light duty vehicle CO_2 emission reduction cost curves and cost assessment – the DIONE model" (European Commission Joint Research Centre, 2017), https://ec.europa.eu/clima/policies/transport/vehicles/proposal_en#tab-0-2, p. 53-54

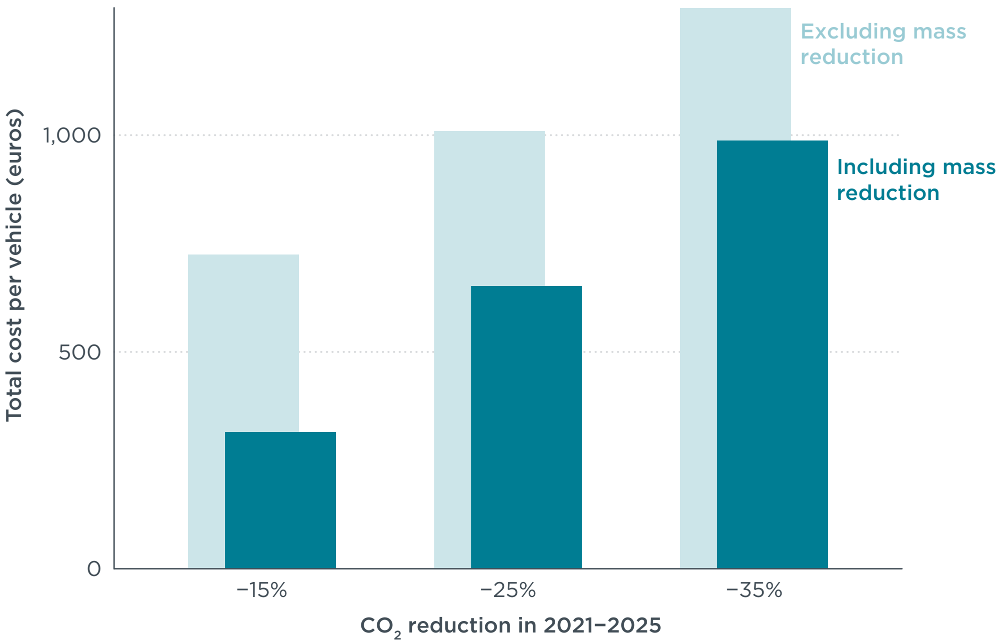

Figure 3. Estimated compliance costs of reducing new passenger car CO_2 emission levels by 15%, 25% and 35% by 2025 compared to a 2021 starting point of 95 g/km in NEDC terms.

How much lightweighting is disincentivized depends on the slope of the mass-based limit value curve. The formula to determine the CO_2 emission target for each individual manufacturer is $E = E_0 + a \times (M - M_0)$, with E_0 being the fleet CO_2 target, *a* the slope of the limit value curve, M the average mass of the manufacturer's vehicle fleet, and M_0 the average mass of all manufacturers. While slope *a* is fixed for the entire duration of the regulation, the M_0 parameter is updated every three years (every two years beginning in 2024) to account for changes in the average mass of the new vehicle fleet. This adjustment is done to ensure that, on average, the fleet target E_0 is reached, even if the average mass of all manufacturers' vehicles increases. Irrespective of this (indirect) correction mechanism for the average mass of all manufacturers, it is the slope of the limit value curve that determines the disincentive for lightweighting. The steeper the limit value curve, the more CO_2 heavier vehicles are allowed to emit, and the higher the disincentive for lightweighting. A flatter slope reduces the disincentive for lightweighting.

The slope of the limit value curve is set based on the relationship between vehicle CO_2 emission values and vehicle mass, as observed on the market. Figure 4 plots the historical relationship between the two variables for each year from 2001 to 2016. The plot shows that the sales-weighted market relationship between CO_2 emissions and mass flattened over time, from more than 0.09 (g/km)/kg in 2001 to approximately 0.04 (g/km)/kg in 2016. This means that, on average, a vehicle that was 100 kg heavier than another one, would have had 9 g/km higher CO_2 emissions in 2009 but only 4 g/km in 2016. It is important to point out that this market relationship between CO_2 emissions and mass is not the same as the physical relationship. Instead, the market relationship reflects not only differences in mass but also differences in other parameters: for example, the fact that heavier vehicles tend to also have a higher engine power, which by itself explains part of the higher CO_2 emission levels.

Figure 4. Relation between CO_2 emissions and vehicle mass in 2001–2016 based on sales-weighted linear regression analyses. Round markers denote average mass and CO_2 emissions of new vehicles in each year.

The slope of the limit value curve was set at 0.0457 (g/km)/kg for the 2012–2019 time period and at 0.0333 (g/km)/kg for the 2020–2024 time period, reflecting a 27% reduction for all vehicle manufacturers (going from the 2015 target of 130 g/km of CO_2 to the 2021 target of 95 g/km of CO_2). Crucially, between 2012 and 2015, the slope in the regulation was lower than the relation between CO_2 emissions and vehicle mass in the market. As long as that was the case, manufacturers did not have an outright incentive to increase vehicle mass, although some of the incentive to lightweight vehicles was offset by the limit value curve. Since 2016, however, this is no longer the case. For the first time, the market relation is lower than the slope of the limit value curve, which means that manufacturers—on average—have an incentive to sell heavier vehicles because the resulting average increase in CO_2 emission values would be lower than the increase in their CO_2 targets (see Figure 5).

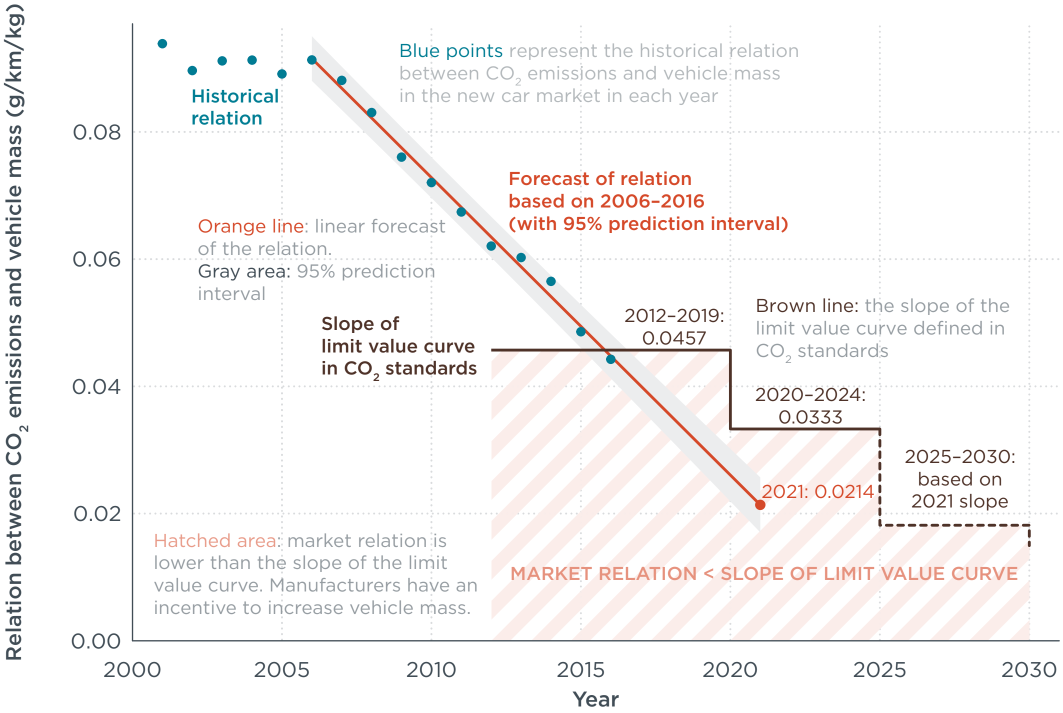

Figure 5. Historical and projected development of the relation between CO_2 emissions and vehicle mass in the new passenger car market.[9] For comparison: Historical and proposed slope of limit value curves in CO_2 standards.

Manufacturers would continue to have an incentive to increase vehicle mass if the trend in the market relation between CO_2 emissions and vehicle mass continues to decline at the same rate as in 2006–2016. There is reason to suspect that it will, in particular because of the deployment of electrified vehicles, which tend to have a higher mass and significantly lower CO_2 emissions than conventional vehicles.

In addition to these market developments, according to the current regulatory proposal from the EC, 2025 and 2030 CO_2 fleet targets would be calculated based on the 2021 fleet target. For example, the 2025 fleet CO_2 target would be set 15% lower than the 2021 fleet target. The 2021 fleet target is the weighted average of the individual manufacturers' 2021 CO_2 targets. Those individual targets for 2021, on the other hand, are calculated taking into account average mass for each manufacturer in 2020 and 2021. As long as a manufacturer's fleet in 2020 and 2021 is heavier than the average fleet reference mass, the resulting manufacturer's target will be higher than for the average market. Problematic in this context is the fact that the EC proposal already defines the 2020 and 2021 average fleet reference mass as 1,380 kg, and does not foresee any correction mechanism in case the average fleet mass in 2020–2021 turns out to be higher or lower than expected. That way, each individual manufacturer has an additional incentive to increase the mass of its vehicle fleet in 2020–2021, in order to secure a higher CO_2 target for the years to come.

9 The market trend refers to the regression coefficient of vehicle mass in a weighted univariate linear regression of vehicle CO_2 emissions on mass. This regression coefficient is the basis for the definition of the slope of the limit value curve in CO_2 standards.

ALTERNATIVE REGULATORY OPTIONS

For the 2025 and 2030 CO_2 standards, there are, in principle, three possibilities to address the drawbacks of the mass-based utility parameter.

1. REMOVE THE UTILITY PARAMETER ALTOGETHER

Removing the utility parameter would simplify the regulation, making it less complex to implement. Barriers to lightweighting would be removed, thereby lowering the compliance cost for vehicle manufacturers. In principle, there are then three options: (a) switch to a system that sets the same absolute CO_2 target in g/km for every manufacturer; (b) switch to a system that requires the same percentage CO_2 reduction for every manufacturer; or (c) set percentage reduction targets that are individual to each manufacturer. In all three cases, there would no longer be a disincentive for lightweighting. If a manufacturer opted to reduce the average mass of its vehicle fleet, the CO_2 savings achieved would fully count towards future target compliance. If, on the other hand, a manufacturer increased the average mass of its fleet, it would need to counterbalance the resulting CO_2 increase with additional technology deployment. Setting the same percentage reduction target for each manufacturer would work in favor of those manufacturers that are currently selling heavier vehicles. They would be allowed to keep the competitive advantage of selling heavier vehicles with higher CO_2 emissions, while manufacturers of lighter vehicles could only start selling heavier vehicles if they compensated by deploying more efficiency technologies. Setting the same absolute target for each manufacturer, on the other hand, would require higher g/km CO_2 reductions from those manufacturers that are currently selling heavier vehicles. The argument in support of such an approach could be that premium manufacturers could more easily market more innovative technologies to their customers. Finally, setting reduction targets for each manufacturer individually could open the standards, and the regulators, to criticism for not applying the same rules to everyone and instead relying on behind-the-curtain deals with manufacturers.

2. USE VEHICLE FOOTPRINT INSTEAD OF MASS AS THE UTILITY PARAMETER

Switching to footprint as the utility parameter would fully reward manufacturers that lightweight their vehicles. Figure 6 illustrates how, under a mass-based limit value curve, part of the CO_2 reduction from lightweighting would be offset by a more stringent CO_2 target. Under a footprint-based limit value curve, however, the manufacturer would benefit from the full amount of CO_2 reduction. As a result, lightweighting would no longer face a competitive disadvantage compared to other compliance options, and overall compliance costs for manufacturers would decrease.

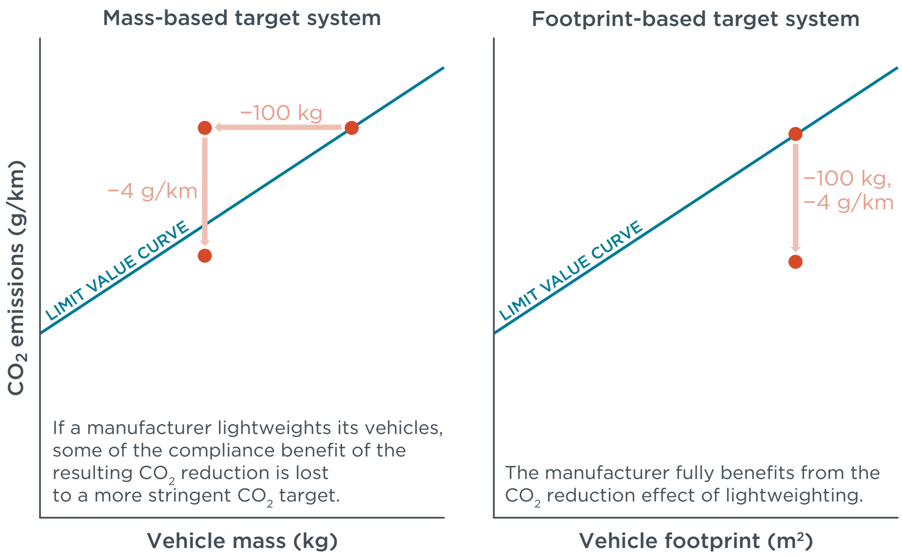

Figure 6. Mass reduction in a mass-based CO_2 target system (left) and in a footprint-based system (right).

3. RETAIN MASS AS THE UTILITY PARAMETER, BUT ADJUST THE UNDERLYING TARGET SLOPE

Retaining mass as the utility parameter would not only require regular updates of the actual average fleet mass M_0, as is already the case in today's regulation, but also of the slope *a* of the limit value curve, in order to account for recent market developments and to avoid creating an incentive to increase vehicle mass. For the 2015 CO_2 regulation, the EC used a linear regression of CO_2 emissions on vehicle mass in 2006 and flattened the resulting slope by 40%, partly to prevent a future mass increase.[10] For 2021–2025, the EC could take a similar approach, flattening the current market slope by a certain degree. For the years beyond 2025, the slope of the utility parameter should be updated at least biannually, like the average fleet mass M_0, to take into account recent market developments as quickly as possible and to avoid any misleading incentives for vehicle manufacturers. In addition, the EC could define a cap for the maximum allowed slope for the years beyond 2025. However, adjusting the slope *a* by itself will not be sufficient. To prevent manufacturers from increasing the mass of their vehicle fleets in 2020–2021, in an effort to secure a higher CO_2 target for the years to come, a correction mechanism needs to be built in. That mechanism would correct the 2025 and 2030 fleet CO_2 targets for the actual average 2020 and 2021 fleet mass instead of using a predefined value of 1,380 kg, as the current regulatory proposal does.

SUMMARY AND CONCLUSIONS

Light-duty vehicle CO_2 standards in the EU are indexed to vehicle mass. Using mass as the utility parameter disincentives vehicle lightweighting, thereby unnecessarily limiting the range of compliance options and increasing the compliance cost for manufacturers. This disincentive for lightweighting is likely to gain importance in future years, and even develop into an incentive for increasing vehicle mass.

10 M. Fergusson et al., "Possible regulatory approaches to Reducing CO_2 emissions from cars" (Institute for European Environmental Policy, TNO, CE Delft, December 2007), https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/technical_notes_ia_en.pdf

For the 2025 and 2030 CO_2 standards, the European Parliament and European Council could deviate from the original EC proposal, remove the utility parameter, and switch to a fixed absolute CO_2 target value or a fixed CO_2 percentage reduction target for all manufacturers. That would simplify the regulation and increase the incentive for lightweighting.

Alternatively, the European Parliament and Council could continue using a utility parameter but transition to vehicle footprint instead of mass. This transition would remove disincentives related to lightweighting and reduce overall compliance costs, but the standard would remain as complex as today.

As the least invasive but also least impactful option, the European policymakers should consider fixing two loopholes that could otherwise undermine CO_2 standards. First, the proposed slope of the limit value curve is no longer flatter than the relation between CO_2 emissions and vehicle mass in the market and thereby provides an incentive to increase vehicle mass. That shortcoming could be addressed by flattening and regularly updating and capping the slope *a*. Second, with the current regulatory proposal, each manufacturer would have an incentive to increase the mass of its vehicle fleet by 2020–2021, as a means of securing a higher CO_2 target for the years to come. To prevent this, the 2025 and 2030 fleet CO_2 targets could be corrected for the actual average 2020–2021 fleet mass, instead of using a pre-defined value of 1,380 kg as the current regulatory proposal does.