INTRODUCTION

The European Commission has imposed the binding requirement to achieve climate neutrality by 2050 through the European Climate Law.¹ To align the heavy-duty vehicle (HDV) sector with this commitment, the European Commission is required to revise the CO₂ standards by 31 December, 2022.² In its current form, the regulation fails to bring the needed reductions in CO₂ with annual HDV CO₂ emissions projected to increase by a total of 8% by 2050 relative to 2019 under the currently adopted policies.³ The standards oblige a reduction in the average CO₂ emissions from most new trucks of 15% by 2025 and 30% by 2030, relative to a 2019/2020 baseline, but a projected 44% increase in freight activity over the period 2020–2050 greatly diminishes the CO₂ reduction benefit of the standards.⁴

The review clause must address a variety of points (otherwise known as modalities), within the current CO₂ standards:

» The appropriateness of the CO₂ target for 2030 and the introduction of CO₂ targets for 2035 and 2040

» Extending the standards to non-regulated vehicles

» Adjusting the incentive mechanism through the zero- and low-emission vehicle factor and accounting for zero-emission range in its calculation


ICCT POSITION BRIEF | RECOMMENDATIONS FOR REVISING THE MODALITIES OF EUROPE’S HDV CO₂ STANDARDS

Accounting for synthetic and advanced renewable fuels in the CO₂ standards
Introducing an engine-based standard
Assessing the appropriateness of the credit and debt system
Introducing a mechanism to allow manufacturers to trade their emission credits

This brief details each of these modalities and provides recommendations for their amendment which would align the HDV sector with the European Climate Law which strives to achieve climate neutrality by 2050.⁵ We first present an overview of the CO₂ standards in their current form, then discuss each of the modalities below.

A BRIEF OVERVIEW OF THE HDV CO₂ STANDARDS

The setting of the first HDV CO₂ standards in the EU was a long and complex process, which required the establishment of three separate regulations, with each building upon the last:

1. The Certification Regulation - (EU) 2017/2400: The CO₂ emissions from most HDVs must be determined using VECTO, a vehicle simulation tool.
2. The Reporting and Monitoring Regulation – (EU) 2018/956: Manufacturers must report the certified CO₂ emissions of their HDVs covered under (EU) 2017/2400 on an annual basis.⁶
3. CO₂ Standards for Trucks – (EU) 2019/1242: Manufacturers are required to reduce certified emissions from most new trucks by 15% by 2025 and 30% by 2030, relative to a 2019/2020 baseline. The CO₂ standards are based on the emissions monitored and reported in accordance with (EU) 2018/956.

Critically, all of these regulations do not apply to all vehicles. Approximately 72% of HDVs sold are required to determine and report their CO₂ emissions under the Certification Regulation, and 63% of new HDVs are required to reduce their emissions by 2025 and 2030 under the CO₂ standards.⁷ Each year, the certified CO₂ emissions related to all new vehicles which fall under the scope of the Certification Regulation must be determined through the use of a simulation tool, VECTO. In VECTO, HDVs are split into groups based on their vehicle parameters, such as number of axles, gross vehicle weight, and body type. Vehicle groups which are covered in the CO₂ standards are further broken down into sub-groups based on their engine power and cab type.

Certified emissions determined by VECTO, in terms of gCO₂/tonne-kilometre (tkm), are averaged across all manufacturers for every sub-group over each period. The resulting emissions established for each sub-group over the period from July 2019 to June 2020 serve as the common baseline emissions for each manufacturer from which emissions will need to be reduced. However, each manufacturer’s specific target is dependent on their fleet composition. A thorough analysis of these baseline data has been published in a previous ICCT report.⁸

---


⁶ In parallel, Member States must also report basic data on all new truck registrations at the national level on a yearly basis.

⁷ Based on annual sales data supplied by IHS Global SA; Copyright © IHS Global SA, 2022.

Two key flexibilities also exist in determining each manufacturer’s compliance with the standard, both of which will be evaluated by the European Commission in the upcoming revision. A zero- and low-emission vehicle (ZLEV) factor is applied to the manufacturer’s reduction target and corresponds to a value between 1 and 0.97, depending on the manufacturer’s share of zero- and low-emission vehicles. Manufacturers may also accumulate credits over the regulation period by overachieving what is required by the standard and use them to offset any debts accumulated (or vice-versa) in earlier or later periods to avoid penalties.

Vocational vehicles, broadly defined as any vehicle not intended for the delivery of goods (such as a dump truck, or a concrete mixer), are not required to comply with the CO2 standards. Buses, coaches, trailers, and light and medium trucks are also outside of the scope of the CO2 regulation, as they weren’t covered by the certification regulation when the CO2 standards were adopted. The upcoming revision offers the possibility to extend the scope of the CO2 standards to cover these vehicles.

RECOMMENDATIONS FOR THE REVISION OF THE MODALITIES TO THE HDV CO2 STANDARDS

THE APPROPRIATENESS OF THE CO2 TARGET FOR 2030 AND THE INTRODUCTION OF CO2 TARGETS FOR 2035 AND 2040

In their current form, the CO2 standards oblige a reduction in the average CO2 emissions (in terms of gCO2/tkm) from the majority of new trucks of 15% in 2025 and 30% in 2030, relative to a 2019/2020 baseline. No targets are set for the period beyond 2030. The HDV sector will likely need to almost entirely decarbonize its annual fleet emissions by 2050 to comply with the European Climate Law.9 The currently adopted HDV CO2 standards fall far short of achieving such a target, with reductions in new fleet emissions largely offset by projected increases in freight activity. In the absence of more stringent CO2 standards beyond 2030, total fleet emissions from HDVs are projected to increase by 8% in 2050 relative to 2019.10 A major element of the review of these standards is the consideration of an update to the 2030 target and an introduction of targets for 2035 and 2040 to align the HDV sector with Europe’s aim of achieving climate neutrality by mid-century.

Recommendation

The 2030 CO2 reduction target should be increased to 60%, and targets of 90% and 100% should be introduced for 2035 and 2040, respectively.

A recent ICCT analysis provides an in-depth look into the reduction targets necessary in 2030, 2035, and 2040 for the EU-27 to align the HDV sector with the ambitions of the European Climate Law.11 A brief synopsis is presented here.

The landscape for zero-emission trucks and buses has changed drastically since the inception of the CO2 standards. Most major manufacturers of HDVs have pledged to significantly increase their production of zero-emission vehicles in the coming decades. Taking a sales-weighted average of all pledges, by 2030 zero-emission vehicles alone will reduce the average emissions of new HDVs by 41%, which is significantly beyond the currently established 30% target.

---

9 The European Green Deal laid out the ambition for transport to achieve a 90% reduction in annual emissions by 2050 to contribute towards climate neutrality. The share that road freight will play in this is dependent on the decarbonization efforts of other modes, particularly aviation and shipping. We analyze a fair contribution from road freight in Mulholland, Miller, Braun, Sen, Ragon, and Rodriguez, “The CO2 Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets.”

10 “The CO2 Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets.”

11 “The CO2 Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets.”
More significant commitments have been made for the long-term; Daimler Truck has pledged to fully phase out sales of the internal combustion engine truck by 2039, 12 Scania by 2040, 13 and all remaining major manufacturers have pledged to end the sale of “fossil-free vehicles” by 2040. 14 If these manufacturers achieve 100% zero-emission vehicle sales by 2040 and implement consistent efficiency improvements in the internal combustion engine trucks produced up to this point, emission reductions would be closely in line with Europe’s climate commitments, i.e., a 96% reduction in annual HDV emissions by 2050 relative to 2019. However, these goals are not certain to be followed without binding regulation, and as such, the manufacturer pledges should represent the minimum level of stringency to be considered in the review of the CO₂ standards.

To make these manufacturer-led pledges a reality and, consequently, commit Europe’s HDVs sector to a deep decarbonization pathway, the targets established in the HDV CO₂ standards should be increased from the current 30% reduction required by 2030 to at least 60% in 2030, and complemented with new reduction targets of at least 90% in 2035 and 100% in 2040.

Figure 1 shows how each major European truck manufacturer would perform compared to these targets, based on their announced zero-emission heavy-duty vehicle (ZE-HDV) deployment pledges, and if these pledges were supplemented with a 3% annual efficiency improvement until the technical potential of the internal combustion vehicle is met. The 3% annual efficiency improvement rate is considered technically feasible for manufacturers to achieve based on our own assessments.

---

Figure 1. Manufacturer CO₂ emission trajectories based on announced pledges towards zero-emission vehicles and assuming a 3% annual efficiency improvement. The ICCT proposed trajectory reflects emissions reductions of 60% in 2030, 90% in 2035, and 100% in 2040.

Four of these seven manufacturers (MAN, Daimler Truck, Scania, and Volvo) are on track to achieve a 60% reduction by 2030 if they meet their ZE-HDV deployment pledges, supplemented by consistent energy efficiency improvements. Two manufacturers are on track to achieve both a 90% reduction in 2035 and a 100% reduction in 2040 (Daimler Truck and Scania). Setting such targets would provide regulatory certainty to manufacturers who already have ambitious ZE-HDV deployment targets.

EXTENDING THE STANDARDS TO NON-REGULATED VEHICLES

The HDV CO₂ standards are currently only applicable to truck classes which accounted for 63% of total annual EU-27 HDV sales in 2021. Significant additional emission reductions can be achieved by extending the standards to non-regulated classes. A prerequisite for vehicles to be introduced into the HDV CO₂ standards is for them to have their CO₂ emissions certified under the Certification Regulation.

---

15 Based on annual sales data supplied by IHS Global SA; Copyright © IHS Global SA, 2022.
Currently, HDV models that make up 85% of annual vehicle sales have their CO₂ emissions certified, following a recent amendment to the original regulation.\(^{17}\)

Trailers do not emit CO₂ but there exists a variety of alterations applicable to them which improves their efficiency when connected to a tractor, enabling the possibility for trailers to be covered by the CO₂ standards.\(^{18}\) As with HDVs, CO₂ standards cannot be applied to trailers without them first being covered by the Certification Regulation. Trailers have recently been certified through their own separate regulation,\(^{19}\) but have not yet been subject to CO₂ standards.

The review of the CO₂ standards will consider an extension of its scope to currently unregulated vehicles. This offers an opportunity for the CO₂ standards to be extended to vehicles which are currently covered by the Certification Regulation, but not by CO₂ standards, including trailers.

**Recommendation**

*The CO₂ standards should be extended to cover all unregulated vehicles which are covered by the Certification Regulation. Separate CO₂ standards should be created for trailers, as well as for buses and coaches.*

Significant fleetwide decarbonization from HDVs will only be possible if the emissions from all vehicles—including trucks, buses, coaches, and vocational vehicles—are regulated, as feasible. To achieve such levels of decarbonization, the scope of the CO₂ standards should be extended to include all vehicles covered by the Certification Regulation.

The share of HDVs which have their emissions certified under the Certification Regulation represent 95% of the annual CO₂ emissions from the HDV sector (see Figure 2), while just 70% of HDV emissions are covered under the CO₂ standards.\(^{20}\) Extending the CO₂ standards to all vehicles covered under the Certification Regulation would regulate nearly all HDV-related CO₂ emissions in the EU-27.

---


\(^{20}\) Emission values were calculated by using CO₂ emission factors generated from the monitoring and reporting data from the EEA and applying in-house estimates for vehicle classes which were not covered.
One challenge related to extending the scope of the regulation to currently unregulated vehicles is the establishment of a different baseline against which HDV emission reductions must be benchmarked. To rectify this, a new set of baselines will be required.

**Setting a new baseline**
For the vehicles currently regulated by the CO\textsubscript{2} standards, emissions reported over the period July 2019–June 2020 form the baseline emissions, and the targets of 15\% and 30\% for 2025 and 2030 are relative to the data collected over that period. Other HDVs covered by the Certification Regulation but not by the CO\textsubscript{2} standards did not report their emissions over this same period, but will have to do so in the near future (see Figure 3).
Implementation dates for the certification of emissions

- Regulated HDTs (4, 5, 9, and 10)
- Non-regulated MDTs (1, 2, 3)
- Non-regulated HDTs (11, 12, 16)
- Trailers
- Other MDTs (1s, 53, 54)
- Primary buses/coaches (P31-P40)
- All buses/coaches (31-40)
- Other HDVs

**Figure 3.** Various implementation dates of the Certification Regulation for HDVs in the EU-27. The blue bars represent potential dates for the setting of a new baseline for unregulated vehicles. The numbers below the HDV classes represent the specific VECTO groups.

The specific CO₂ emissions target for each manufacturer is based off a reference CO₂ value for each subgroup. Including additional vehicles into the CO₂ standards thus requires a definition of their CO₂ emission reference values, which is already defined for the regulated vehicle subgroups, but has yet to be defined for the certified but unregulated subgroups. To determine these values, a second baseline period needs to be introduced for VECTO groups which are covered by the current Certification Regulation but not by the CO₂ standards. The reference value for these vehicles should be based on the earliest available reporting period, July 2020–June 2021 for vehicles covered under the original Certification Regulation (EU) 2017/2400. For the vehicles most recently added under the amendment to the Certification Regulation, a third baseline to determine their reference CO₂ values is required and should be set as soon as possible, i.e., over the reporting period July 2024–June 2025. The earliest baseline for trailers and buses will be over the reporting periods January–December 2024, and January–December 2025, respectively (see Figure 3).

Zero-emission vehicles should not be included in the calculation of the baseline emissions. Accounting for electric vehicles in the baseline unfairly penalizes manufacturers who have already made, or will make, significant progress in the electrification of their vehicles. For some HDV segments, most notably for buses, the

---

21 See Appendix for a complete list of the VECTO categorizations.
rate of adoption of zero-emission vehicles has been exceptionally high. 22 Setting a baseline based only on conventionally fueled vehicles enables a fairer reference for all manufacturers to benchmark their emission reductions.

**Extending the CO\textsubscript{2} standards**

For medium and heavy trucks, CO\textsubscript{2} certified vehicles that are currently unregulated should conform to the same targets applicable for regulated vehicles, as outlined in the previous section. For vocational trucks, engine standards should be set, which we describe in more detail in a subsequent section.

For trailers, separate CO\textsubscript{2} standards should be established. Semi-trailers do not produce CO\textsubscript{2} emissions, as they are non-motorized. However, a variety of modifications to the standard semi-trailer can be made to significantly improve the performance of the motorized tractor. The establishment of a trailer specific certification regulation has enabled a procedure for certifying the emissions attributable to a semi-trailer design. 23 Emissions can be reduced through introducing aerodynamic technologies, such as boat-tails, side skirts, or reducing the gap between the trailer and the tractor, rolling resistance technologies, such as low-rolling resistance tires, and light-weighting technologies, such as material substitution in the chassis frame and body structure. Previous ICCT research has shown that a combination of these technologies can achieve up to a 10% reduction in CO\textsubscript{2} emissions by 2030 in a long-haul cycle, and more than 7% in a regional cycle. 24

For buses, including coaches, separate CO\textsubscript{2} standards should also be established. Buses are electrifying rapidly, even in the absence of regulatory requirements for manufacturers to produce lower emitting vehicles, driven by strong demand-side measures at both the Member State and the city level. 25 The European Commission established a non-binding goal for all buses in operation to be zero-emission by 2050. 26 Our previous analysis showed that to make this a reality, new targets should be established corresponding to a 90% reduction target in 2030, and 100% by 2035, relative a new baseline. 27 Manufacturers have already shown their willingness to comply with such a target. The largest bus manufacturer in the EU, Daimler Truck, has pledged to only sell zero-emissions city buses from 2030. 28 The second biggest manufacturer, MAN, plans for 50% of sales to be equipped with an electric drive by 2025. 29

---

24 Ragon and Rodríguez, “Benefits of Extending the EU Heavy-Duty CO\textsubscript{2} Emissions Standards to Other Truck Segments.” These values are based on a trailer driven by the most common HDV vehicle group, 5-LH, which is responsible for over half of Europe’s HDV emissions.
27 “The CO\textsubscript{2} Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets.”
ADJUSTING THE INCENTIVE MECHANISM THROUGH THE ZERO- AND LOW-EMISSION VEHICLE FACTOR AND ACCOUNTING FOR ZERO-EMISSION RANGE IN ITS CALCULATION

The HDV CO₂ standards include a bonus mechanism to promote the deployment of zero-emission heavy-duty vehicles in the form of a zero- and low-emission vehicle (ZLEV) factor. The ZLEV factor is applied to the manufacturer’s fleet average specific CO₂ emissions and can, in effect, reduce a manufacturer’s emission reduction target by up to 3%.

Manufacturers who increase their sales share of ZLEVs benefit from a reduced overall target during two phases; the super-credits phase which runs to 2025, and the benchmark phase which runs to 2030.

Under the super-credits phase, zero-emission vehicles are double counted toward the CO₂ emissions reduction target, and low-emission vehicles can be up to double counted, depending on their emissions. The super-credits phase will not be amended in the revision, and more information on this mechanism is described in a previous ICCT paper.⁵⁰

The benchmark phase, which runs from 2026 onward, may be amended in the upcoming revision. During this phase, manufacturers that have a ZLEV share of 2% or more are rewarded through a different ZLEV factor. Manufacturers are not faced with any penalties if they do not meet the 2% threshold. As in the super-credits phase, the ZLEV factor is also capped at a minimum of 0.97, meaning ZLEV shares greater than 5% relaxes the CO₂ targets by a maximum of 3%. Low emission vehicles are counted as between 0 and 1 vehicles, depending on their CO₂ emissions.

Recommendation

The ZLEV factor should be phased out after 2030. In the benchmark phase, a vehicle’s contribution to the ZLEV factor should be dependent on its zero-emission range. Incentives should be weighted towards the higher emitting vehicle categories through the mileage and payload weighting factor.

In its current form, the ZLEV factor offers little positive benefit to the CO₂ standards. In the period 2026–2030, it sets a benchmark which is easily achievable, and most manufacturers are likely to surpass even in its absence. Five of the seven major truck manufacturers in Europe have committed to deploying between 35% and 60% zero-emission vehicles by 2030—over seven times what is needed to achieve the 5% benchmark cap (see Figure 4). As such, the ZLEV factor in its current form only serves to allow the remaining conventional vehicles to emit higher levels of CO₂ and hinder technological progress in internal combustion engine efficiency improvements, without serving its intended purpose of incentivising the increased deployment of ZLEVs.

---
Furthermore, in the current system, all zero-emission trucks contribute equally towards the ZLEV factor calculation, regardless of vehicle type or zero-emission range. Therefore, there is also no additional regulatory incentive to invest in Europe’s most commonly used vehicles, such as the long-haul tractor trailer, compared to a less commonly used vehicle group, like the urban delivery truck.

The ZLEV factor for the super-credits phase should be amended to increase market competitiveness of electric trucks by ensuring that the deployment targets established by manufacturers are targeted at the highest emitting HDVs. The ZLEV factor should be redesigned to better incentivize investments into high-range zero-emission vehicle segments which are traditionally high-emitting vehicles. Such a redesign could be implemented through introducing two new mechanisms, described below.

**Accounting for a vehicle’s mileage and payload.** The first mechanism would incentivize manufacturers to invest in zero-emission technologies for the highest-emitting vehicle types. This can be addressed by applying the mileage and payload weighting (MPW) factor to the ZLEV calculation, which is determined as the product of the vehicle’s mileage and payload relative to the equivalent for the most common truck group in Europe, 5-LH. This would credit manufacturers for investing in the research, development, and manufacturing of ZE-HDVs with a higher average annual mileage and payload, which are traditionally higher-emitting vehicles.

Using such a mechanism, a zero-emission 5-LH vehicle and 9-LH vehicle, two of the highest polluting VECTO sub-groups responsible for 72% and 12% of regulated HDV emissions in 2020, respectively, would receive a counting of 1 and 0.9, respectively, towards the ZLEV factor, as shown in Table 1. In comparison, a regional delivery 9-RD vehicle, the sub-group which was responsible for 3% of the annual HDV emissions in 2020, would receive a counting of 0.15 towards the ZLEV factor.
Table 1. Regulated vehicles and their mileage, payload, and annual CO₂ emissions share parameters.

<table>
<thead>
<tr>
<th>VECTO group</th>
<th>Annual mileage (km)</th>
<th>Average daily distance (km)</th>
<th>Payload (kg)</th>
<th>MPW</th>
<th>CO₂ emissions share in 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-UD</td>
<td>60,000</td>
<td>175</td>
<td>2,650</td>
<td>0.1</td>
<td>0%</td>
</tr>
<tr>
<td>4-RD</td>
<td>78,000</td>
<td>250</td>
<td>3,180</td>
<td>0.15</td>
<td>4%</td>
</tr>
<tr>
<td>4-LH</td>
<td>98,000</td>
<td>300</td>
<td>7,420</td>
<td>0.45</td>
<td>4%</td>
</tr>
<tr>
<td>5-RD</td>
<td>78,000</td>
<td>250</td>
<td>10,258</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>5-LH</td>
<td>116,000</td>
<td>375</td>
<td>13,842</td>
<td>1</td>
<td>72%</td>
</tr>
<tr>
<td>9-RD</td>
<td>73,000</td>
<td>225</td>
<td>6,280</td>
<td>0.29</td>
<td>3%</td>
</tr>
<tr>
<td>9-LH</td>
<td>108,000</td>
<td>350</td>
<td>13,400</td>
<td>0.9</td>
<td>12%</td>
</tr>
<tr>
<td>10-RD</td>
<td>68,000</td>
<td>225</td>
<td>10,258</td>
<td>0.43</td>
<td>0%</td>
</tr>
<tr>
<td>10-LH</td>
<td>107,000</td>
<td>350</td>
<td>13,842</td>
<td>0.92</td>
<td>4%</td>
</tr>
</tbody>
</table>

Note: Average daily distance is calculated through the annual mileage reference values, and our own assumptions on the daily utilization rate.

**Accounting for zero-emission range.** Under the current mechanism, a ZEV with a 200 km electric range receives the same benefits through the ZLEV factor as one with 1,000 km range. To disincentivize manufacturers from investing in low-range vehicles to avail of the ZLEV factor benefit, zero-emission vehicles should receive a graded contribution to the ZLEV factor based on their zero-emission range relative to its expected daily range requirement.

**Modifications to the ZLEV factor**
The current mechanism for ZLEVs may be better aimed at longer ranged and higher mileage vehicles by multiplying the contribution of each ZLEV with two scalars. The first would be through simply introducing the MPW into the calculation. The second would set a value between 0 and 1 based on a vehicle’s zero-emission range relative to its reference mileage.

As an illustrative example, Table 2 shows the calculated zero-emission range factor and the overall ZLEV contribution from a variety electric truck models currently available for sale. Such a system would reward high-range vehicles such as the Daimler Truck eActros LongHaul, which has an electric range 33% greater than the daily range for the sub-group, while it would penalize low range trucks such as Scania’s P Series 4x2 which only delivers 70% of the desired range of the sub-group.
Table 2. ZLEV contribution of various zero-emission trucks

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Zero-emission model</th>
<th>Sub-group</th>
<th>Zero-emission range (km)</th>
<th>Sub-group daily range (km)</th>
<th>ZERange Factor</th>
<th>MPW</th>
<th>Proposed ZLEV contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daimler Truck</td>
<td>eActros 300 4x2</td>
<td>4-RD</td>
<td>300</td>
<td>250</td>
<td>1.00</td>
<td>0.15</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>eActros 300 6x2</td>
<td>9-RD</td>
<td>300</td>
<td>225</td>
<td>1.00</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>eActros LongHaul</td>
<td>5-LH</td>
<td>500</td>
<td>375</td>
<td>1.00</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>GenH2</td>
<td>5-LH</td>
<td>1000</td>
<td>375</td>
<td>1.00</td>
<td>1</td>
<td>1.00</td>
</tr>
<tr>
<td>Volvo Trucks</td>
<td>Volvo FH Electric 4x2</td>
<td>5-LH</td>
<td>300</td>
<td>375</td>
<td>0.80</td>
<td>1</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Volvo FL Electric 4x2</td>
<td>4-RD</td>
<td>300</td>
<td>250</td>
<td>1.00</td>
<td>0.15</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Volvo FL Electric 4x2</td>
<td>4-LH</td>
<td>300</td>
<td>300</td>
<td>1.00</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>MAN</td>
<td>eTGM 6x2</td>
<td>9-RD</td>
<td>190</td>
<td>225</td>
<td>0.84</td>
<td>0.29</td>
<td>0.24</td>
</tr>
<tr>
<td>Scania</td>
<td>P Series 4x2</td>
<td>5-LH</td>
<td>250</td>
<td>375</td>
<td>0.67</td>
<td>1</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>P Series 6x2</td>
<td>9-LH</td>
<td>250</td>
<td>350</td>
<td>0.71</td>
<td>0.9</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>FCEV 6x2</td>
<td>9-LH</td>
<td>400</td>
<td>350</td>
<td>1.00</td>
<td>0.9</td>
<td>0.90</td>
</tr>
<tr>
<td>DAF</td>
<td>FT 4x2</td>
<td>5-LH</td>
<td>280</td>
<td>375</td>
<td>0.75</td>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>FAN 6x2</td>
<td>9-LH</td>
<td>220</td>
<td>350</td>
<td>0.63</td>
<td>0.9</td>
<td>0.63</td>
</tr>
<tr>
<td>Renault</td>
<td>T electric</td>
<td>5-LH</td>
<td>300</td>
<td>375</td>
<td>0.80</td>
<td>1</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>C electric</td>
<td>9-LH</td>
<td>300</td>
<td>350</td>
<td>0.86</td>
<td>0.9</td>
<td>0.77</td>
</tr>
</tbody>
</table>


ACCOUNTING FOR SYNTHETIC AND ADVANCED RENEWABLE FUELS IN THE CO2 STANDARDS

Some consideration is being given to a fuels crediting mechanism, whereby manufacturers contribute to their CO2 emission reduction targets by purchasing credits from renewable synthetic and advanced alternative fuel suppliers.

Fuel producers are already required to blend a quantity of renewable fuel in accordance with the mandates established by the recast of the Renewable Energy Directive (RED II).31 Due to this pre-existing requirement for fuel producers, for a fuels crediting system to viably contribute towards greenhouse gas (GHG) emission reductions, significant efforts are required to prevent fuels that are already counted towards the RED II transport target to count towards the CO2 standards.

Although fuels crediting was considered but not included in the final CO2 standards for light-duty vehicles, the topic of fuels crediting is again generating interest for HDVs, with some manufacturers expecting renewable fuels to be used in their combustion engines.32

**Recommendation**

Fuels crediting should not be allowed in the CO2 standards.

Fuels crediting would promote the supply of synthetic e-fuels, which face high production costs, and biofuels, which are in limited supply and susceptible to

sustainability risks. Further, fuels crediting may risk the integrity of the standards due to the potential of double counting with the RED II and distract manufacturers from focusing their innovation efforts toward the deployment of technologies capable of reducing vehicle CO₂ emissions.\textsuperscript{33} We highlight three of the biggest concerns with a fuels crediting mechanism below.

**The production of e-fuels is inefficient and prohibitively expensive**

E-fuels are produced over several stages which require renewable electricity as a direct input if they are to be considered as fully sustainable. The combined costs of these stages makes e-diesel expensive to produce. A recent ICCT analysis puts the cost of domestic production in the range of €1.96–€3.81 per litre in 2020,\textsuperscript{34} dropping to a range of €0.86–€2.10 per litre by 2050.\textsuperscript{35} Using these projections, Figure 5 shows the range of the marginal cost of compliance for HDV manufacturers to reduce their fleet emissions by 1 gCO₂/tkm per vehicle in 2025 and 2030 through fuels crediting of e-fuels.\textsuperscript{36} Assumptions for the annual mileage and survival of each sub-group used to calculate these values is described in a recent ICCT report.\textsuperscript{37}

![Figure 5. The cost of compliance for manufacturers to meet the 2025 and 2030 targets through e-fuels (red bars) benchmarked against the cost of penalties if manufacturers did not invest in any efficiency improvements from the baseline.](image)

The cost of compliance penalties in 2025 is lower than the marginal cost of fuels crediting through e-fuels. In 2030, the cost of penalties is akin to our optimistic estimate for e-fuels. Thus, it would likely be cheaper for manufacturers to do nothing than to comply with their targets through purchased e-fuels credits. It would also


\textsuperscript{34} Excluding tariffs, taxes, and distribution costs

\textsuperscript{35} Zhou, Searle, and Pavlenko, “Current and Future Cost of E-Kerosene in the United States and Europe.”

\textsuperscript{36} As only the production cost is considered, and assuming the fuel supplier does not profit from the sale of the credits, these assumptions may be viewed as conservatively low.

\textsuperscript{37} “The CO₂ Standards Required for Trucks and Buses for Europe to Meet Its Climate Targets.”
be substantially more expensive than the estimated costs required to meet the CO₂ standards through efficiency improvement measures, calculated by the Impact Assessment of the CO₂ Standards to be €390/gCO₂/tkm in 2025 and €1,216/gCO₂/tkm per vehicle in 2030. This analysis and the underlying assumptions are detailed further in the Appendix.

**Biofuels are in low supply and are exposed to sustainability risks**

Biofuels have much lower costs compared to e-fuels. However, most biofuels used in transport today are produced from food and feed materials, which are associated with significant land use change emissions. While wastes and residues can be used to produce low-GHG alternative fuels, their potential to decarbonize the road sector is limited due to competing uses with other transport sectors. Biofuels made from wastes and residues are in low supply, and may indirectly increase emissions due to undesired land use change if strict sustainability criteria are not followed.

The RED has been amended to reduce these sustainability risks, but these risks are not reflected in the GHG savings assigned to the feedstocks in the RED II. For example, some land use change emissions are not included, thus simply referencing the GHG savings of a fuel in a fuels crediting system could have undesirable effects for the climate. In addition, feedstocks such as food and waste oils might not be capped or excluded from the alternative fuels crediting scheme as in the RED II. Using food or feed-based feedstocks would not achieve significant carbon savings.

Even if adhering to strict sustainability guidelines that would allow only advanced biofuels additional to the RED II to count towards the CO₂ standards, their combustion would still be associated with air pollutant emissions of nitrogen oxides at levels similar to conventional fuels and with particulate matter emissions, albeit at a comparatively lower level, which increase the risk of morbidity associated diseases. Investments into zero-emission vehicles provide guaranteed improvements into air quality.

**Fuel credits may be double counted towards fuel supplier existing obligations**

Fuel suppliers already have a variety of emission reduction obligations. Under the RED II, fuel suppliers are required to provide a minimum of 14% renewable energy of the total amount consumed in road and rail transport by 2030. This target is under review and could increase as a part of the Fit for 55 package.

A manufacturer should only be eligible to use fuel credits towards its CO₂ targets if they are supplemental to a fuel producer’s quota under the RED II. Under the Directive, the European Commission must establish a database to enable the tracing of fuels eligible towards compliance. Such a database could help ensure that fuels...
credits are not double counted towards both a manufacturer’s CO₂ reduction target and the fuel producer’s obligation under the RED II. However, it would need to be capable of tracking every single liter of alternative fuel produced to enable cross-checking across policy targets and between Member States. Since the RED II is a directive, tracking how fuels are counted towards either the RED or the CO₂ standards could be left to the individual Member States, each of which has its own system for determining RED II compliance.

INTRODUCING AN ENGINE-BASED STANDARD

The CO₂ standards in their current form apply to the full vehicle, allowing manufacturers to comply with their emissions reduction requirement through the adoption of multiple measures. These technologies include vehicle road load technology such as aerodynamic improvements and low rolling resistance tires, and engine technology such as engine friction reduction, combustion optimization, or zero-emission adoption.

As part of the revision, the European Commission plans to evaluate the impact of introducing a separate engine standard for vehicles, as is in place in the United States and Canada. Such a system offers a viable opportunity for certain vehicles, particularly vocational vehicles such as refuse and dump trucks, to contribute to emission reductions. Vocational vehicles benefit proportionately less from efficiency improvements through road load technologies, particularly aerodynamic improvements, but can still avail of emission reductions through engine standards.

Vocational vehicles are not covered under the scope of the CO₂ standards due to their comparatively low mileage with respect to the regulated vehicle groups. They make up 1% of the annual vehicles sold in the regulated VECTO categories according to the baseline monitoring and reporting data covering the period July 2019–June 2020.

Recommendation

The scope of the CO₂ standards should be extended to vocational vehicles through the implementation of engine standards which require an emissions reduction through engine specific technologies.

Technologies capable of reducing CO₂ emissions for engines exist, and there is no viable reason for why such technologies cannot be employed in vocational vehicles. The main arguments for why the introduction of an engine standard is worthwhile are detailed below.

A vocational engine standard encourages CO₂ emission reductions in parallel with Euro VII emission standards compliance

The European Commission’s proposal for Euro VII emission standards establishes stricter limits for emissions of nitrogen oxides (NOx). Some technologies aimed at reducing NOx emissions come at the expense of higher fuel consumption, and thus higher CO₂ emissions, while others can improve both concurrently.

Setting a complementary standard for CO₂ reduction on the engine would ensure manufacturers optimize engine improvements around both CO₂ and NOx reductions, rather than focusing on technologies which reduce NOx at the expense of fuel consumption. A previous ICCT analysis has identified a list of engine technologies compatible with both NOx and CO₂ reductions.  

**Engine improvements for vocational vehicle may also be adopted by other regulated HDV segments**

Engines used in vocational vehicles are not always exclusive to these vehicles. Table 3 shows the percentage of non-vocational vehicles which use the same engine as a vocational vehicle, based on the monitoring and reporting data. Vocational vehicles only represented 1% of vehicle sales, but 31% of non-vocational vehicles shared a common engine with a vocational vehicle. Introducing a requirement for vocational vehicles to lower their emissions through engine improvements will filter these technological advances into these other vehicle types, including vehicles not covered by the Certification Regulation.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Non-vocational vehicle sales</th>
<th>Vocational vehicle sales</th>
<th>Sales of non-vocational vehicles using the same engine as a vocational vehicle</th>
<th>Percentage of non-vocational vehicle sales using the same engine as a vocational vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daimler Truck</td>
<td>101,917</td>
<td>2,528</td>
<td>7,634</td>
<td>7%</td>
</tr>
<tr>
<td>DAF</td>
<td>35,974</td>
<td>1,683</td>
<td>34,790</td>
<td>97%</td>
</tr>
<tr>
<td>Renault Trucks</td>
<td>25,205</td>
<td>-</td>
<td>17,315</td>
<td>69%</td>
</tr>
<tr>
<td>IVECO</td>
<td>21,707</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>Volvo Trucks</td>
<td>43,945</td>
<td>134</td>
<td>38,723</td>
<td>88%</td>
</tr>
<tr>
<td>Scania</td>
<td>51,400</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td>MAN</td>
<td>32,463</td>
<td>-</td>
<td>-</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>312,611</strong></td>
<td><strong>4,345</strong></td>
<td><strong>98,462</strong></td>
<td><strong>31%</strong></td>
</tr>
</tbody>
</table>

Notes: Data is based on the engine certification number provided in the EEA monitoring and reporting database. In the case of Renault Trucks, while they have no registered vocational vehicles, some vehicles use the same engine as a Volvo Trucks vocational vehicle, as both fall under the umbrella of Volvo Group.

**Measuring compliance would not present a significant additional burden**

Manufacturers are already required to monitor and report engine-related CO₂ emissions for their vehicles on an annual basis to the European Environment Agency. Cumulative cycle CO₂ emissions for new HDVs are determined annually through the World Harmonized Transient Cycle (WHTC) and the World Harmonized Stationary Cycle (WHSC) test, which is used to determine compliance with the Euro pollutant emissions standards. Determining compliance of an engine standard can be based off this pre-existing framework.

**ASSESSING THE APPROPRIATENESS OF THE CREDIT AND DEBT SYSTEM**

The CO₂ standards include flexibilities for manufacturers to comply with their CO₂ emission targets through a credit and debt system. Manufacturers can accumulate credits over the reporting periods for the years 2019–2029 and can accumulate debts over the reporting periods for the years 2025–2029. The points at which a manufacturer accumulates credits or debts is summarized in Figure 6.
Figure 6. HDV CO\(_2\) standards credit and debt mechanism. Hatched area represent where neither credits nor debts are accumulated.

For the year 2025, if a manufacturer accumulates any debts (measured in gCO\(_2\)/tkm), it can use any credits accumulated from 2019 through 2024 to offset them. The credits accumulated between 2019 and 2024 can only be used in 2025. If the manufacturer still has any remaining debts after using up all their credits, and this exceeds 5% of the target times the number of vehicles sold, they must pay a fine of €4,250/gCO\(_2\)/tkm per vehicle.

The same process applies in the second phase, between 2026 and 2029. If at any point in these years, a manufacturer accumulates debts beyond 5% of the target that it cannot offset with credits earned since 2025, they must pay a fine of €4,250/gCO\(_2\)/tkm per vehicle.

The credit and debt system ends in 2030. From then onwards, manufacturers must pay a penalty of €6,800 per vehicle for each gCO\(_2\)/tkm they are above the 2030 target.

Recommendation

The credit and debt mechanism should only be extended past 2030 if the stringency of the 2030 target is significantly increased.

A credit and debt system provides manufacturers flexibility in managing their transition to a lower emission fleet. Early action is incentivized, allowing ambitious manufacturers to bank credits to offset any future debts. In effect, this averages out a manufacturer’s fleet emissions over the compliance period, allowing for their target to be met in a more cost-effective way.

However, caution should be exercised if the credit and debt system is to be continued forward, particularly if the CO\(_2\) reduction targets for 2030 are not significantly
increased. Most manufacturers have pledged to sell shares of zero-emission vehicles by 2030 that go far beyond the currently imposed 30% target (see Figure 4). As a result, they’re on track to accumulate a significant number of credits. For example, if Scania, Volvo Trucks and Daimler Truck achieve their 50% zero-emission sales targets, they will generate cumulative credits worth €4.4 billion euro in 2030 alone.

If these manufacturers are allowed to use the credits generated over the period 2025-2029 to comply with their 2030 target, it opens the possibility of these high-achieving manufactures significantly increasing their fleet emissions for this compliance year. For the same reason, it’s critical that the lifetime of credits is held exclusive to the compliance period (e.g., credits earned in the period 2026-2030 cannot be carried over to beyond 2031). This would prevent manufacturers who achieve a high share of zero-emission vehicles early on from over-relying on these credits to meet their reduction targets in the later years and divesting from emission reduction technologies. A continuation of the credit and debt system should only be allowed if the 2030 target is set in accordance with manufacturer pledges (i.e., 60%).

INTRODUCING A MECHANISM TO ALLOW MANUFACTURERS TO TRADE THEIR EMISSION CREDITS

Emission credits are non-transferrable across manufacturers. A credit trading mechanism would allow manufacturers to combine their emissions reduction efforts to comply with their targets. This would effectively mean under-performing manufacturers could purchase credits from their over-performing counterparts.

The light-duty vehicle CO₂ standards allows for a similar mechanism through pooling, and this is under consideration for the revision of the HDV CO₂ standards. In the original HDV CO₂ standards, the Impact Assessment advised against the inclusion of a pooling system under claims that, despite reducing compliance costs, it risks reducing competitiveness in a market which only has a limited number of individual manufacturers, and thus would reduce the number of technologies available for sale.50

Recommendation
Allow manufacturers to trade their credits to other manufacturers, but only if the stringency of the 2030 target is significantly increased.

The HDV market is more consolidated than the light vehicle market, with the top seven truck manufacturers comprising 98% of the total sales in 2021.51 The concern with a credit mechanism raised by the Impact Assessment is that it may disincentivize a manufacturer from producing zero- or low-emitting vehicles (ZLEVs) by allowing them to trade with another who has over complied with their reduction target by producing a higher volume of ZLEVs. The Impact Assessment claims that this would result in reducing both the competitiveness and diversity of ZLEVs available in the market. Contrary to this reasoning, we argue that a credit trading mechanism may actually increase diversity in the HDV market.

While the market for conventional HDVs is segregated, the market for zero-emission HDVs is growing in diversity. Whereas the top seven truck manufacturers were responsible for 98% of the sales of conventional vehicles, this reduces to 86% when only considering zero-emission trucks (see Figure 7). There is also an increasing number of smaller HDV manufacturers entering the market who are focusing only on zero-emission vehicle production. For trucks, these include Emoss, Volta Trucks,

---


51 Based on annual sales data supplied by IHS Global SA; Copyright © IHS Global SA, 2022.
Einride, Tevva, and E-Trucks Europe, and for buses it includes BYD, Ebusco, Karsan, Golden Dragon, and Caetano Bus. Zero-emission manufacturers will naturally generate emission credits for every ZE-HDV built. Allowing a trading mechanism would offer a new source of capital for these smaller manufacturers to gain a better foothold in the market.

However, a credit trading system should only be considered if the stringency of the CO₂ standards are increased in accordance with manufacturer pledges (i.e., 60%). As previously discussed, some major manufacturers are on track to generate a significant number of credits. Without increasing the stringency of the standards, these manufacturers would dominate the credit trading market, risking a reduction to the overall competitiveness for zero-emission vehicles.

**SUMMARY OF POLICY RECOMMENDATIONS**

The HDV CO₂ standards in their current form offer little climate benefit, with the limited scope of the standards failing to achieve any significant emission reductions by 2050. The revision of the CO₂ standards offers the opportunity to rectify this. This brief highlights the most significant elements to be considered under the revision and provides recommendations on how to align the HDV sector with Europe’s long-term climate commitments. We summarize these points below and further summarize in Figure 8.

The **2030 CO₂ reduction target should be increased to 60%, and targets of 90% and 100% should be introduced for 2035 and 2040, respectively.** These targets align with the latest pledges of the major HDV manufacturers in Europe and would deliver a 96% reduction in annual HDV CO₂ emissions by 2050.

The **CO₂ standards should be extended to include all unregulated vehicles which are covered by the certification regulation.** Regulating the emissions of all HDVs
which must certify their emissions would regulate 95% of annual HDV CO₂ emissions. Separate CO₂ standards should be created for trailers, as well as for buses and coaches.

**The ZLEV factor should be phased out after 2030.** In its current form, the ZLEV factor provides little incentive for manufacturers to invest in zero-emission technology, as the majority of them have already pledged to exceed the benchmark by up to ten-fold by 2030. The mechanism can be improved in the short term by weighting the incentives base on the vehicle’s zero-emission range and mileage and payload weighting factor.

**Fuels crediting should not be allowed in the CO₂ standards.** Sustainable e-fuels are prohibitively expensive, and biofuels are linked to issues of sustainability and availability. Fuel credits are also at risk of being double counted with fuel suppliers pre-existing obligations under the Renewable Energy Directive.

**The scope of the CO₂ standards should be extended to vocational vehicles** through the implementation of engine standards which require an emissions reduction through engine specific technologies.

**The credit and debt mechanism should be extended past 2030,** but only if the stringency of the 2030 target is significantly increased. This would offer additional flexibility in compliance while preventing manufacturers from over-relying on credits to meet later reduction targets and divesting from emissions reduction technologies.

**Manufacturers should be allowed to trade their credits to other manufacturers,** but only if the stringency of the 2030 target is significantly increased. Doing so would open a source of revenue for smaller manufacturers who focus solely on zero-emission deployment, thus increasing competitiveness in the market.
Increase the 2030 target to 60%, introduce targets of 90% for 2035 and 100% for 2040

Regulate all certified vehicles

<table>
<thead>
<tr>
<th>Reduction targets relative to baseline</th>
<th>2030</th>
<th>2035</th>
<th>2040</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-15%</td>
<td>60%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>2025</td>
<td>2030</td>
<td>2035</td>
</tr>
<tr>
<td></td>
<td>60%</td>
<td>90%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>2035</td>
<td>2035</td>
<td>2040</td>
</tr>
<tr>
<td></td>
<td>7-10%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Differentiate the ZLEV factor based on a vehicle’s MPW and zero-emission range

Do not introduce a fuels crediting system

Introduce engine standards for vocational vehicles

Extend the banking and borrowing system past 2030, but only if the stringency of the standards is increased

Allow for manufacturers to trade their credits

Figure 8. Summary of recommendations for the HDV CO₂ standards review
APPENDIX: CALCULATION OF E-FUELS MARGINAL COMPLIANCE COSTS

This paper presented the marginal cost of a manufacturer reducing their fleet average specific CO₂ emissions by 1 gCO₂/tkm through the use of e-fuels. This appendix outlines the assumption behind these calculations.

For every regulated VECTO vehicle, we calculated the total cost of e-fuel production that would be required if these vehicles were run only on e-diesel, using the following equation:

\[
\text{Lifetime efuel production cost}_{SG} = \sum_{Y=0}^{30} \text{Mileage}_{SG,Y-Y_0} \times \text{Survival}_{SG,Y-Y_0} \times \text{efuel cost}_Y
\]

Where \(SG\) is the VECTO sub-group, \(Y\) is the year, \(Y_0\) is the first year of the analysis (i.e., 2025 or 2030), \(\text{Mileage}\) is the annual mileage of a vehicle of age \(Y-Y_0\), \(\text{Survival}\) is the probability of a vehicle surviving to age \(Y-Y_0\), and \(\text{efuel cost}\) is the production cost of e-diesel.

Our assumptions behind the survival and annual mileages of each VECTO group and projections on the production cost of e-diesel are detailed in the Appendix of a previous ICCT paper. The resulting lifetime mileage, given through the product of annual mileage and vehicle survival, is shown below in Table A1.

Table A1. Characteristics of the regulated VECTO subgroups

<table>
<thead>
<tr>
<th>VECTO category</th>
<th>Sales (2021)</th>
<th>Lifetime Mileage (vkm)</th>
<th>gCO₂/tkm</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-UD</td>
<td>89</td>
<td>513,706</td>
<td>307.2</td>
</tr>
<tr>
<td>4-RD</td>
<td>18,166</td>
<td>675,294</td>
<td>198.8</td>
</tr>
<tr>
<td>4-LH</td>
<td>15,613</td>
<td>791,286</td>
<td>106.8</td>
</tr>
<tr>
<td>5-RD</td>
<td>835</td>
<td>583,331</td>
<td>85.8</td>
</tr>
<tr>
<td>5-LH</td>
<td>121,547</td>
<td>977,660</td>
<td>57.2</td>
</tr>
<tr>
<td>9-RD</td>
<td>10,861</td>
<td>603,511</td>
<td>112.0</td>
</tr>
<tr>
<td>9-LH</td>
<td>25,569</td>
<td>888,553</td>
<td>65.8</td>
</tr>
<tr>
<td>10-RD</td>
<td>48</td>
<td>721,016</td>
<td>84.5</td>
</tr>
<tr>
<td>10-LH</td>
<td>7,462</td>
<td>861,553</td>
<td>59.1</td>
</tr>
</tbody>
</table>

After quantifying the production cost for e-fuels to cover a vehicle’s total life, we took the share which would be required to reduce a manufacturer’s fleet average specific CO₂ emissions by 1 gCO₂/tkm. The weighted average of all manufacturer’s fleet average specific CO₂ emissions in the baseline reporting period amounted to 52.8 gCO₂/tkm. To reduce this value by 1 gCO₂/tkm would require 1.9% of the total fuel from every manufacturer’s truck to be covered by e-fuels. We applied this 1.9% share to the lifetime e-fuel production cost for every vehicle, and multiplied it by the vehicle’s sales share in 2021 as follows:

\[
\text{Marginal cost of efuel compliance} = 1.9\% \times \sum_{SG} \text{Lifetime efuel production cost}_{SG} \times \text{SalesShare}_{SG}
\]

Where \(\text{SalesShare}\) is calculated using the total sales of HDVs in 2021.

We compared this marginal cost to the current penalties which have only be set for 2025 (€4,250 for every excess gCO₂/tkm), and 2030 (€6,800 for every excess gCO₂/tkm).

52 “Current and Future Cost of E-Kerosene in the United States and Europe.”