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REGULATORY COSTS OF EURO 7 – FINDINGS FROM AN INDUSTRY SURVEY

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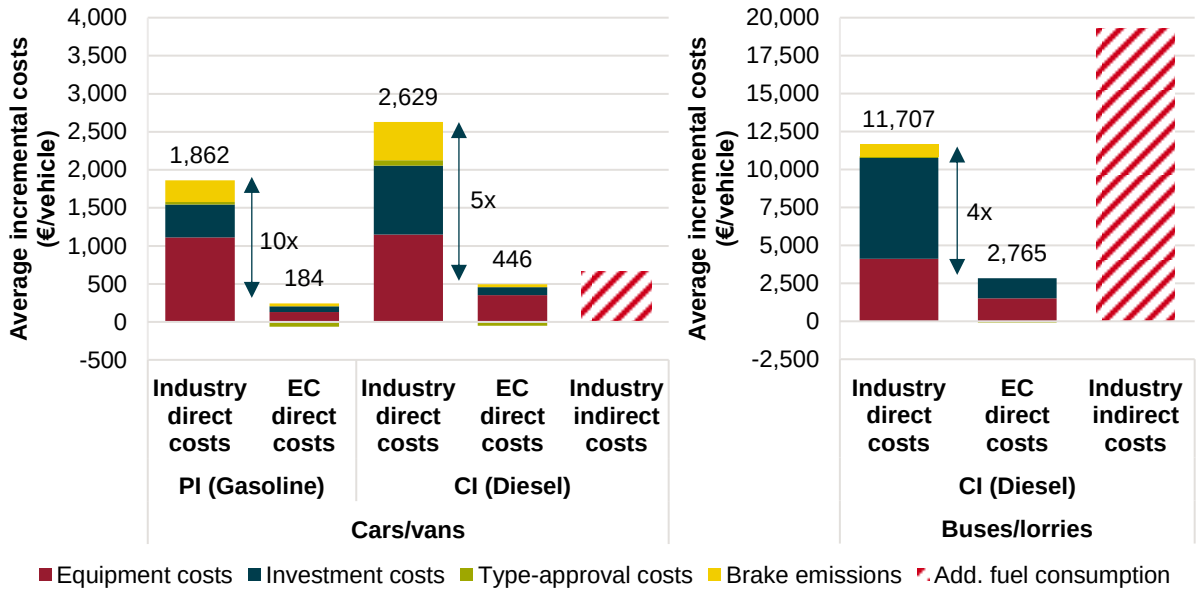
Executive summary

In the EU, emission standards for new vehicles set limits for the emission of gaseous and particle exhaust pollutants. In November 2022, the European Commission (EC) published a proposal for a new "Euro 7" regulation addressing passenger cars as well as light-duty and heavy-duty vehicles, which sets stricter emission limits and test conditions, replacing the existing "Euro 6 and Euro VI" standards. Compliance[1] with this proposed Euro 7 regulation will increase manufacturing costs of new Euro 7 vehicles. In addition, there are indirect costs such as increased fuel consumption which will add to the total costs of ownership for consumers.

The Euro 7 Impact Assessment (IA) by DG GROW estimates additional direct costs for vehicles in the order of 180-450 € for cars/vans and 2,800 € for buses/lorries. However, indirect costs to consumers and higher manufacturing costs for battery-electric vehicles (e.g. for battery durability) are not considered in the Euro 7 Impact Assessment.

The European Automobile Manufacturers Association (ACEA) has asked Frontier to provide an independent and compliant evaluation of incremental Euro 7 costs per vehicle based on estimates by industry experts and to compare these cost estimates with figures used in the Euro 7 Impact Assessment. Below we summarise our key findings:

Figure 1 Incremental costs of Euro 7: Industry vs EC IA estimates



Source: *Frontier Economics based on OEM data, EC Impact Assessment tables 21 and 23*

Note: *Indirect cost estimates reflect an illustrative example of undiscounted cost for additional fuel consumption over the lifetime of a Euro 7 vehicle. Such costs were not considered in the Euro 7 Impact Assessment.*

[1] In the following, compliance with the Euro 7 proposal is assumed. Truck/bus industry experts remain concerned whether the Euro 7 proposal is technically feasible at all. Cars/vans industry experts also noted that compliance and the ability to provide appropriate cost estimates includes, for example, that the on-road test boundary conditions focus on realistic scenarios and not over emphasize practically irrelevant extreme situations.

Industry experts estimate the direct cost increase from Euro 7 for vehicles with internal combustion engines (ICE) up to 10 times higher than the cost estimate in the Impact Assessment

Industry experts report average incremental direct costs of Euro 7 (compared to Euro 6 or Euro VI) – which are largely driven by equipment and investment costs – of **2,000 € per ICE car/van** and **12,000 € per diesel bus/lorry**. These estimates are between **four to ten times higher** than the estimates reported in the Euro 7 Impact Assessment (see Figure 1 above).

Unconsidered indirect costs to consumers from higher fuel consumption can exceed the total cost reported in the Euro 7 Impact Assessment (in particular for lorries)

In addition to direct costs, industry experts report an increase in fuel consumption to achieve the proposed Euro 7 requirements (e.g., additional fuel to warm up the catalyst from cold start). This leads to material additional indirect costs for consumers and logistic companies.

Take for example a long-haul truck with a mileage of around 1 million km and a fuel consumption of 25 l/100km. At a diesel price of 2 €/l, a 3.5 % fuel increase would result in **17,500 € over the assumed mileage of the truck**.[2] Similarly, the fuel cost increase of Euro 7 for passenger cars/vans would be around **700 € per vehicle**.

These indirect costs alone, which are **ignored in the Impact Assessment**, already exceed the total per vehicle cost of Euro 7 considered in the Impact Assessment (see Figure 1 above).

The Euro 7 Impact Assessment does not capture further effects, such as costs for reducing tyre abrasion emissions, a cost increase for battery-electric vehicles and likely limitations in entry model choice for consumers

In addition to direct and indirect costs for ICE vehicles, there are further costs from the proposed Euro 7 regulation which are not captured in the Euro 7 Impact Assessment:

- **Tyre emissions** – Euro 7 regulation includes tyre abrasion emissions for the first time.[3]
- **Higher costs for battery electric vehicles** – Industry experts report higher manufacturing costs in the order of about 180 €/vehicle for cars/vans and 750 €/vehicle for buses/lorries due to non-exhaust emission limits and battery durability requirements.
- **Limited consumer choice** – Consumers of more affordable entry-level cars might face substantially higher prices than today as a result of disproportionate costs increases or even terminated production of certain models in this vehicle segment. For instance, some passenger car manufacturers (OEMs) pointed out that meeting Euro 7 targets would require introducing automatic transmission not yet standard in entry level models. As a consequence, some customers may be forced to switch to more expensive models.

[2] 17,500 € = 3.5% * 1,000,000 km * 25 l/100km * 2 €/l. This rough calculation uses conservative and rounded assumptions.

[3] Respondents to the questionnaire could not provide accurate cost estimates since tyre producers were not part of the study.

Introduction

In the EU, emission standards for new vehicles set limits for the emission of local pollutants including – among others – carbon monoxide, nitrogen oxides and particle matter.[4] The current standard for passenger cars/vans – Euro 6 – was introduced in 2014 and subsequently updated in 2017 and 2020 ("Euro 6d"). The latest standard for heavy-duty vehicles – Euro VI – was introduced in 2013 and subsequently updated to Euro VI-E in 2020.

In November 2022, the European Commission (EC) published a proposal for a new combined "Euro 7" standard which sets stricter emission limits than Euro 6 and Euro VI and also addresses non-exhaust particle emissions (from brake wear and tyre abrasion). The proposal aims for Euro 7 to be mandatory as of July 2025 for all new light-duty vehicles and as of July 2027 for all new heavy-duty vehicles.

Compliance with the proposed Euro 7 regulation would require OEMs to install additional hardware and invest in the development and roll-out of new technologies – which will affect manufacturing costs of new Euro 7 compliant vehicles. The European Automobile Manufacturers Association (ACEA) has asked Frontier to conduct a study in which we:

- Provide an independent and compliant[5] evaluation of incremental costs per new Euro 7 vehicle based on estimates by industry experts.
- Compare the industry estimates with the cost estimates from the Impact Assessment (IA) for the EC's preferred policy option 3a.[6]

Our analysis of incremental costs is based largely on data provided by ACEA member companies and, thus, reflects industry estimates. We have – to the extent possible to us – checked these industry estimates for consistency and have, where necessary, followed up with respondents for further clarifications.

In the following sections, we will describe our data collection process and analytical approach. We then present the results of our average incremental costs per vehicle separately for cars/vans and for buses/lorries. These results will be compared to the estimates reported by the EC in its Euro 7 Impact Assessment. Finally, we will briefly discuss indirect costs of Euro 7 for consumers which were not considered in the Impact Assessment. We will also provide an estimate for additional fuel costs as an example of such indirect costs. For further detail on the aforementioned sections, we have included an annex at the end of this report.

4 There is a separate regulation of CO_2 emissions, the so-called fleet targets (Regulation (EU) 2019/631 for cars/vans and Regulation (EU) 2019/1242 for heavy-duty vehicles).

5 OEMs act as competitors and are, therefore, prohibited to share sensitive information (e.g. on costs for vehicle components) under EU competition law.

6 The IA cost estimates refer to a study by CLOVE.

Empirical approach – Incremental Euro 7 costs are based on responses from industry experts representing major European vehicle manufacturers

Information gathered in compliant manner through questionnaire covering a broad set of vehicle and cost categories

Our analysis builds on an **industry questionnaire** that has been sent out to ACEA member companies (vehicle manufacturers, "OEMs"). We asked ACEA members to provide estimates for incremental costs under the proposed joint Euro 7 norm (scenario 3a) compared to the current Euro 6 and Euro VI norms. Cost data was provided in Euro per vehicle.

In designing our questionnaire, we consulted with ACEA industry experts on components for various categories of vehicles which are relevant for compliance with Euro 7. We asked respondents for their estimates for a range of different:

- **vehicle categories** (see Figure 2) – based on size and other technical attributes; and
- **cost categories** (see Figure 3) – also including relevant categories which were not considered in the Euro 7 Impact Assessment.

Figure 2 Vehicle categories in the questionnaire

Vehicle class	Cars/vans (M1 & N2)									Buses/lorries (M2, M3 & N2, N3)			
Engine type	PI (Petrol)			CI (Diesel)			BEV			CI (Diesel)[7]		BEV	
Segment	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Large	Small	Large

Source: *Frontier Economics*

Note: *Please note that we asked for separate cost estimates for buses/lorries in our questionnaire. For the following analysis we combine both into a single vehicle class. For further details on our vehicle categorisation, please see our Annex A*

As vehicle categories for our analysis we only use vehicle class and engine type. We decided against a more granular approach where we differentiate our cost estimates further by segments for various reasons:

- **Compliance with confidentiality requirements** – to ensure that no OEM-specific information can be inferred from our findings in those segments with a low number of observations, it is necessary to keep our data aggregated.
- **Unsystematic difference between vehicle segments** – where cost estimates do not vary substantially among segments (in particular for PI cars/vans), further differentiation would not allow to deduce more information.

[7] We have not included the PI (Petrol) engine type for buses/lorries due to their insignificance in the market.

- **Comparability with the EC's estimates** – the EC's Impact Assessment also reports average cost figures across segments, we do the same to allow for a direct comparison with our cost estimates.

Figure 3 Cost categories in the questionnaire

Main cost category	Subcategories	Cost type	Relevant vehicle categories
Direct cost	Exhaust emission control	Recurrent costs	PI and CI vehicles
	Evaporative emission control and ORVR	Recurrent costs	PI (petrol) vehicles
	Onboard emission monitoring (OBM)	Recurrent costs	PI and CI vehicles
	Battery durability	Recurrent costs	BEVs
	Brake emission control	Recurrent costs	All vehicles
	Investment costs	Fixed one-off costs allocated per vehicle	All vehicles
	Type-approval costs	Recurrent costs	All vehicles
Indirect cost	Increased fuel consumption	Recurrent costs	PI and CI vehicles

Source: *Frontier Economics*

Note: *We initially asked OEMs for cost estimates related to tyre emissions but received feedback that these costs are particularly difficult to estimate and would mostly depend on tyre suppliers. We subsequently decided to exclude this cost category from our analysis. We have also given OEMs the possibility to add and describe custom categories of costs and to provide estimates for these additional 'other' costs. Only one respondent used this category and provided a marginal cost increase. We, therefore, decided to exclude the 'other cost' category from our analysis. For further details on our cost categorisation, please see our Annex A*

We mainly **focus on direct costs** (i.e. additional manufacturing costs of Euro 7 vehicles)[8] in our questionnaire but **also cover indirect costs** for consumers and the society, for example, increased fuel consumption that would result from the introduction of Euro 7.

Industry responses to our survey allow for an estimation of average incremental costs for different vehicle categories

In total, we received responses from ten OEMs – six manufacturers of LDVs (cars/vans) and four manufacturers of HDVs (buses/lorries).[9] To **ensure strict compliance** with EU competition law and confidentiality requirements, we anonymised OEM data. Therefore, we are only able to present aggregated information – such as averages – which does not allow to infer individual responses by OEMs.[10]

8 It should be noted that increases in manufacturing costs do not simply lead to equivalent changes in consumer prices (e.g. margin mark-ups have not been considered) but, actually, tend to increase prices even further. In this study, we do not attempt to quantify possible end price increments of Euro 7 vehicles. From the perspective of consumers, our incremental cost estimates should be seen as a lower-bound estimate of potential price increases.

9 We sent out our questionnaire to representatives of 16 OEMs of which 10 have responded (response rate of 63%).

10 For that reason, we exclude statistics which include individual values like minima, maxima or medians from our report.

The responses to our questionnaire cover all vehicle and cost categories, with varying data coverage by vehicle/cost category.[11] This provides sufficient information to calculate robust average cost estimates at an aggregated level (i.e. total incremental costs per vehicle category).

To obtain estimates for direct Euro 7 costs we proceed in two steps:

- We first calculate the average of all responses for each cost category and vehicle category (i.e. vehicle class and engine type) separately.
- We then sum up the averages of each cost category to obtain total incremental costs for a generic vehicle of a given category.[12]

For example, we averaged all industry estimates for each cost category (exhaust emissions, investment costs, etc.) corresponding to a certain vehicle category (e.g. PI cars/vans) and summed up these averages to obtain our total incremental cost estimate for that particular vehicle category.

Incremental Euro 7 costs for ICE cars/vans are about 2,000 €/vehicle and largely driven by costs for hardware, investment but also brake emissions

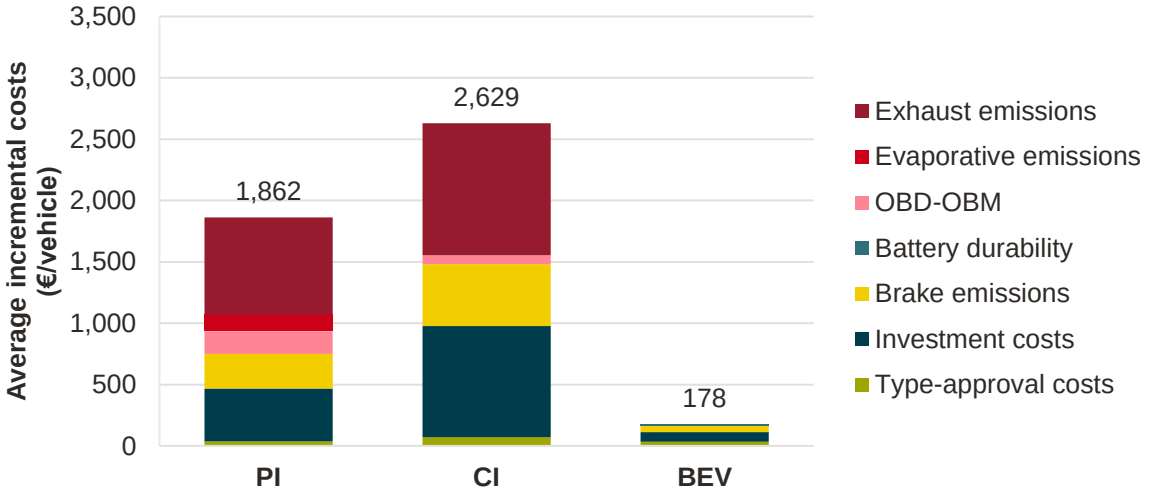
Figure 4 presents average direct costs for passenger cars/vans, broken down into seven cost categories, for the three vehicle categories: petrol cars/vans (PI), diesel cars/vans (CI) and battery electric cars/vans (BEV). We find average direct cost, ranging between c. 180 for BEV up to c. 2,600 € per CI vehicle:

- **Petrol cars/vans** – the reported total incremental costs for petrol cars/vans are about 1,900 €/vehicle. The individual responses of the OEMs on the total costs as well as on the different cost components can differ significantly. The provided cost estimates are rather independent from the size of the vehicles, showing similar values for small, medium or large cars/vans.
- **Diesel cars/vans** – the total incremental costs of diesel cars/vans are ca. 40 % higher than those for the corresponding petrol vehicles at total incremental cost of approx. 2,600 €/vehicle. The range of the responses is quite large. In contrast to the petrol cars/vans, the size of the vehicles correlates considerably with the reported total costs.
- **BEV cars/vans** – total incremental costs for BEV cars/vans are below 200 €/vehicle and lie substantially under the costs of the corresponding ICE vehicles. However, although BEV vehicles do not need exhaust emission control, evaporative emission control or onboard emission monitoring, the introduction of Euro 7 is associated with material costs. There are similar costs across all vehicle size segments.

11 For example, we have received only one response related to BEVs in the buses/lorries category.

12 We do not apply different weights to the responses of individual OEMs (e.g. based on their volumes/market shares) because we risk breaching confidentiality requirements if specific OEM responses can be inferred through their weights.

Figure 4 Direct incremental costs of Euro 7 for passenger cars/vans



Source: Frontier Economics based on ACEA member data

In Figure 5, we analyse the different cost components in detail, ranked from largest to smallest cost category.[13] As petrol and diesel vehicles show several commonalities, we consider them together (internal combustion engine vehicle, or "ICEV") and report BEV costs separately.

Figure 5 Detailed breakdown of cost categories for cars/vans

Cost categories	ICEV	BEV
Exhaust emission control	Largest single cost component with a value of about 800 € per petrol vehicle and about 1,100 € per diesel vehicle. Catalyst reformulation costs and the installation of an automatic gearbox are explicitly mentioned as relevant elements by some OEMs.	Not relevant
Investment	Investment for R&D, the development of new technologies and the upgrade of existing systems/facilities account for about 400 € per petrol vehicle and about 900 € per diesel vehicle. The values reported are usually estimated based on a five-year period[14] (if specified by the OEM).	Investment cost as largest single component make up about 80 €/vehicle.
Brake emissions	Costs for installing components to reduce brake emissions are a quite substantial cost component with	Brake emission costs lie in the range of 50 €/vehicle.

13 Our analysis includes the main cost components of Euro 7. However, tyre emissions are not included as the OEMs were not able to provide proper estimates here.

14 In this case, the investment costs per vehicle reported by the OEM's are the annual investments broken down from a five-year period and the predicted sales volumes.

	about 300 € per petrol vehicle and about 500 € per diesel vehicle.[15]	
OBD-OBM	Onboard emission monitoring costs which basically include the installation of additional sensors lie in the range of about 200 € per petrol vehicle and about 75 € per diesel vehicle.	Not relevant
Evaporative emission control	Costs for the upgrade to a ORVR system are about 150 € per petrol vehicle, while they are not relevant for diesel vehicles.	Not relevant
Type approval costs	Costs for testing and calibrating technologies for new vehicle models make up about 35 € per petrol vehicle and about 70 € per diesel vehicle.	Type approval costs are about 35 €/vehicle.
Battery durability[16]	Not relevant	Battery durable costs as costs to fulfilling battery durability requirements are reported to be about 20 €/vehicle.

Source: Frontier Economics

Incremental Euro 7 costs for buses/lorries are about 12,000 € per diesel vehicle and strongly depend on investment costs

Figure 6 reports the direct average incremental costs for buses/lorries, broken down into the same seven cost categories as for cars and vans, for the two vehicle categories: diesel buses/lorries (CI) and battery electric buses/ lorries (BEV).

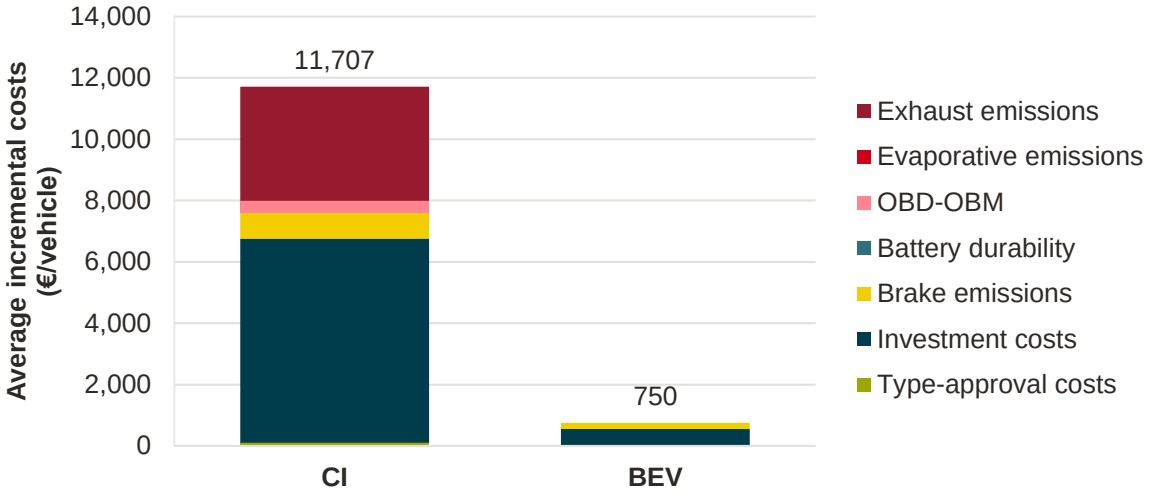
- **Diesel buses/lorries** – the reported total incremental costs for diesel buses/lorries are just short of 12,000 €/vehicle. According to respondents, buses/lorries generally require the same hardware changes to meet the new Euro 7 standard. However, total costs for buses are slightly higher than for lorries, as the lower volumes of buses drive up per vehicle costs compared to lorries. The variation in reported cost estimates differs for different interpretations of the Euro 7 requirements which are yet less clear for heavy-duty vehicles than for light-duty vehicles.[17] Smaller vehicles in this segment only show about half of the costs of their large counterparts.
- **BEV buses/lorries** – the total incremental costs of BEV buses/lorries amount to 750 €/vehicle. This accounts to 6% of the incremental costs of diesel-driven buses/lorries, which is comparable to the relation of BEV and diesel cars/vans.

15 As outlined before, cars/vans are split into petrol and diesel to ensure comparability with the EC's Euro 7 Impact Assessment. Industry experts noted that in the EU market, vans – for which brake emission costs are typically higher than for cars due to their higher weight – predominantly use diesel engines, which drives the differences between fuel types.

16 Battery durability requirements affect costs for both battery-electric vehicles as well as for hybrid vehicles (which are were not considered in this survey).

17 Some respondents in the heavy-duty vehicle segment even state that compliance with Euro 7 in its current proposed form is not achievable.

Figure 6 Direct incremental costs of Euro 7 for buses/lorries



Source: Frontier Economics based on ACEA member data

In Figure 7, we compare the different cost components for the two categories in detail, again ranked according to their size.

Figure 7 Detailed breakdown of cost categories for buses/lorries

Cost categories	Diesel (CI)	BEV
Investment	Investment control costs are the largest cost component with about 6,700 €/vehicle and most components are usually estimated based on a period of five years (if specified by the OEM).[18]	Investment cost as largest single component make up about 550 €/vehicle.
Exhaust emission control	Exhaust emission control costs make up about 3,800 €/vehicle. OEMs list the risk of a stronger electrification (48 V system) to onboard powertrain system, cold start requirements and measures to mitigate the fuel consumption increase generated by extra emission control systems and strategies as possible cost drivers.	Not relevant
Brake emissions	Brake emissions costs are about 840 €/vehicle. The exact brake emission control specifications are still unclear for some OEMs.	Brake emission costs lie in the range of 200 €/vehicle. The exact brake emission control specifications are still unclear for some OEMs.
OBD-OBM	Onboard emission monitoring costs lie in the range of about 400 €/vehicle. Some OEMs report that it is still unclear which broadcasting technology will be used in the future given the rather long lifetime of the vehicle.	Not reported

[18] As for cars/vans, the investment costs per vehicle reported by the OEM's are the annual investments broken down from a five-year period and the predicted sales volumes.

Type approval costs	Type approval costs are about 100 €/vehicle.	Reported as negligible
Battery durability	Not relevant	Reported as negligible if existing battery technologies are used.

Source: Frontier Economics

Direct incremental Euro 7 cost estimates from industry experts are four to ten times higher than in the European Commission's Impact Assessment

In the following section, we compare our average incremental cost findings with those presented in the EC's Impact Assessment. We can only compare those vehicle categories for which we have overlapping cost estimates. For this reason, we do not consider comparisons of estimates for BEVs (which are absent from the Euro 7 Impact Assessment) and Petrol (PI) buses/lorries (which we excluded from our questionnaire).

To compare the incremental cost estimates from our industry survey with those from the Euro 7 Impact Assessment, we have combined components into broader categories. Figure 8 shows how we aggregated cost categories to ensure comparability between both sources.

Figure 8 Cost categories for comparison: Industry vs EC Impact Assessment

Aggregated cost category	Industry survey conducted by Frontier Economics	EC Impact Assessment	
Equipment costs	Exhaust emission control	Hardware costs (part of the EC's 'equipment costs')	
	Evaporative emission control/ORVR		
	Onboard emission control (OBM)		
Investment costs[19]	Investment costs	R&D and related calibration costs including facilities and tooling costs (part of the EC's 'equipment costs')	
Type-approval costs	Type-approval costs	Testing costs	Costs during implementation phase
		Witnessing costs	
		Type-approval fees	
		Administrative costs	
Brake emissions	Brake emission control	NAO brake pads for ICE and MHEV	

Source: Frontier Economics & EC Impact Assessment

Note: For the EC's brake emission control estimate we used costs for non-exhaust components from table 21 in the Impact Assessment (part 2, page 62). Please note that these cost figures are only available for cars/vans.

[19] It should be noted that these aggregated cost categories are not perfectly comparable. The Euro 7 Impact Assessment extrapolates costs for R&D over a relatively long period until 2050. Investment cost estimates provided by the industry, however, are based on five-year amortisation period which is deemed more appropriate by the industry in light of an increasing phase-out of new ICE vehicles on the European market by the mid-2030s.

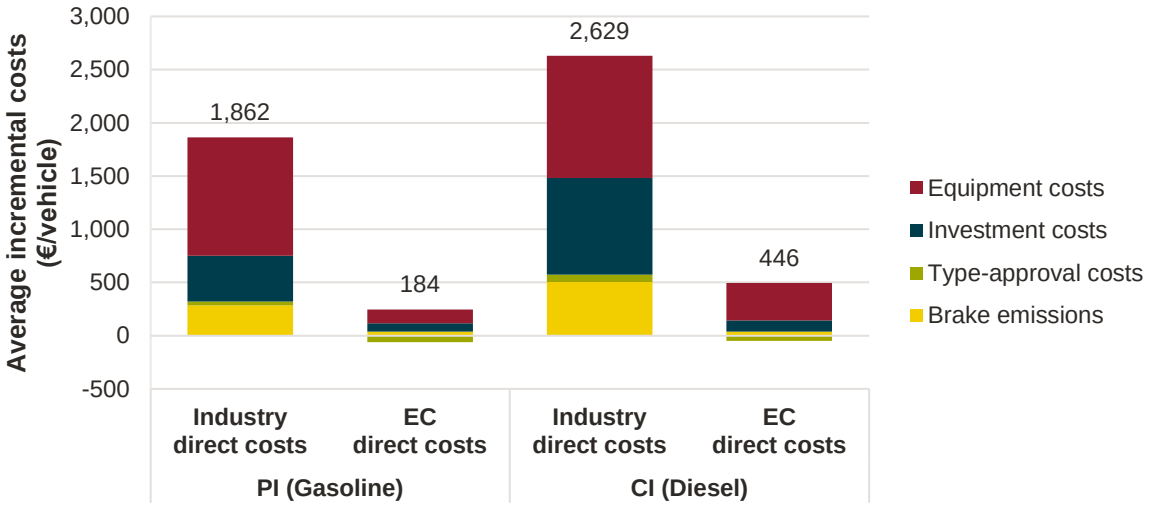
Passenger cars/vans – Industry estimates exceed Euro 7 Impact Assessment cost by factor of five to ten

As shown in Figure 9, average incremental cost for petrol cars/vans estimated by industry experts **exceeds the EC** cost estimate (c. 184 €/vehicle) **by a factor of ten**.[20] Similarly, for diesel cars/vans we also observe a large difference (**a factor of five**) between our cost average and that by EC of about 446 €/vehicle.[21]

These large differences are mostly driven by significant differences in equipment costs for both PI and CI vehicles. Our costs for brake emission control are also significantly higher than the EC's estimates but have relatively less impact on the overall result.

For costs in the context of type-approval, we found marginal cost increases according to industry expectations, whereas the EC expects cost savings from the Euro 7 introduction.[22] Overall, this category only has a relatively small impact on total incremental costs.

Figure 9 Direct costs of Euro 7 for cars/vans: Industry vs Euro 7 IA estimates



Source: Frontier Economics based on ACEA member data, EC Impact Assessment tables 21 and 23

[20] We obtained these figures by adding costs for brake emission control components of 37.5 €/vehicle for ICE and MHEV cars to EC's average regulatory cost figures for PI and CI cars/vans (146.8 and 408 €/vehicle respectively).

[21] Even when using the lowest reported values of the OEMs in the relevant segment, we receive values that lie well above the values of the Euro 7 Impact Assessment.

[22] According to the EC, these cost decreases result from simplified testing and witnessing due to more advanced onboard emission monitoring.

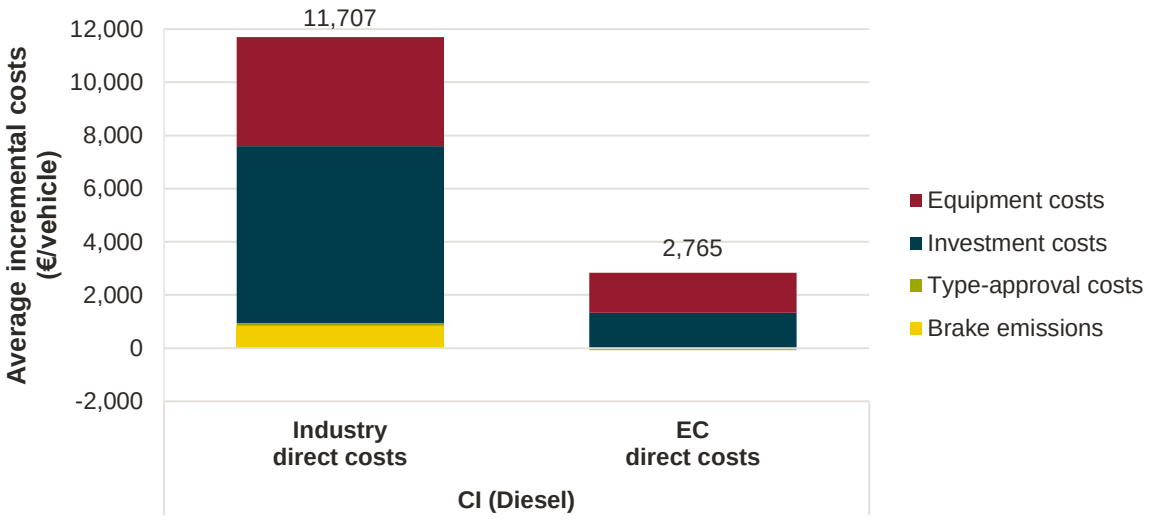
Buses/lorries – Industry estimates exceed Euro 7 Impact Assessment cost by a factor of four

In the heavy-duty category of diesel buses/lorries we find significantly higher incremental costs than the EC. Our average estimate exceeds that of the EC of 2,765 €/vehicle by the factor four (see Figure 10).

Again, our cost differences are mainly driven by different estimates for equipment and investment costs. Unlike for passenger cars/vans, the EC does not provide any cost information about components for brake emission control in the HDV segment. We, therefore, did not consider this cost category in the EC's total cost estimate. Our estimate, on the other hand, includes average industry costs for brake emission controls. This difference further contributes to the gap between both findings, although brake emissions make up a relatively small share of total incremental costs.

Similarly to cars/vans, we find that costs for type-approval have a marginal positive impact on our estimate and a small negative impact on the EC's estimate.

Figure 10 Direct costs of Euro 7 for buses/lorries: Industry vs EC IA estimates



Source: *Frontier Economics based on ACEA member data, EC Impact Assessment table 23*

Note: *Due to the low relevance of petrol ("PI") buses/lorries we did not consider this category. Brake emissions are missing from EC estimate because no cost information is given for buses/lorries in the Impact Assessment.*

Possible reasons for differences between Industry and EC's estimates

The large gap between Industry and EC Impact Assessment estimates clearly raise questions on possible explanations that we have discussed with industry experts. The following issues have been brought forward:

- **Different starting point** – The starting point for the calculation of the cost increment between an existing Euro 6 or Euro VI vehicle and a future Euro 7 vehicle might differ between both approaches. The question is which Euro 6 or Euro VI vehicle is used as a benchmark for the comparison with a Euro 7 vehicle. Currently available Euro 6 or Euro VI vehicles (cars in particular) have widely different technical features across manufacturers, some of which may make it easier to reach compliance with Euro 7. Moreover, there seems to be a significant underestimation of retrofitting costs for smaller passenger cars in the EC's estimates. Unlike manufacturers of upper medium or premium models, many OEMs of smaller, affordable vehicles will have to introduce more updates to their engines, cooling systems and electrification.[23] Industry experts mention that the EC focuses heavily on the exhaust aftertreatment system and neglects additional changes to the fuel system[24] necessary to reduce evaporative emissions.
- **Different end point** – The final products as Euro 7 compliant vehicles assumed under the industry and the EC's cost estimations may also differ. The EC seems to focus on what is needed at minimum to reach compliance. OEMs, on the other hand, have to focus on engineering targets that are well below the limits to address risks – as for example covering any issues regarding public liability – which is likely to result in higher costs.
- **Possible underestimation of total costs in the Euro 7 Impact Assessment** – The EC's Impact Assessment and the CLOVE study, on which it is based, also provide individual cost information for relevant components such as OBM sensors, ORVR and brake pads, which not always appears consistent. A simple sum over these components would suggest higher total costs than those reported by the EC.[25] This raises at least questions about how exactly the EC derived its average cost figures.

Overall, it should be stressed that significant uncertainty around the precise requirements of the current proposal for Euro 7 makes it difficult for both manufacturers and regulators to assess incremental costs precisely at the moment. Rather than focussing on a single number intended to explain incremental costs of Euro 7 compliance, a determination of a cost range might be more appropriate to represent the real conditions and implications.

Additional indirect cost to consumers alone, which are not covered by the Impact Assessment, exceed the estimated total cost of the EC substantially

Apart from direct regulatory costs which we understand as additional costs for manufacturers in the production process of compliant vehicles, the Euro 7 regulation may create further

23 Some specific hardware updates mentioned in our expert discussions were replacement of MPI engines with larger GDIs to reduce average load, installation of compressed air intercoolers, stronger electrification of 48V to onboard the powertrain system, and introduction of automatic transmission instead of manual gearboxes.

24 Such as the introduction of pressurised fuel systems.

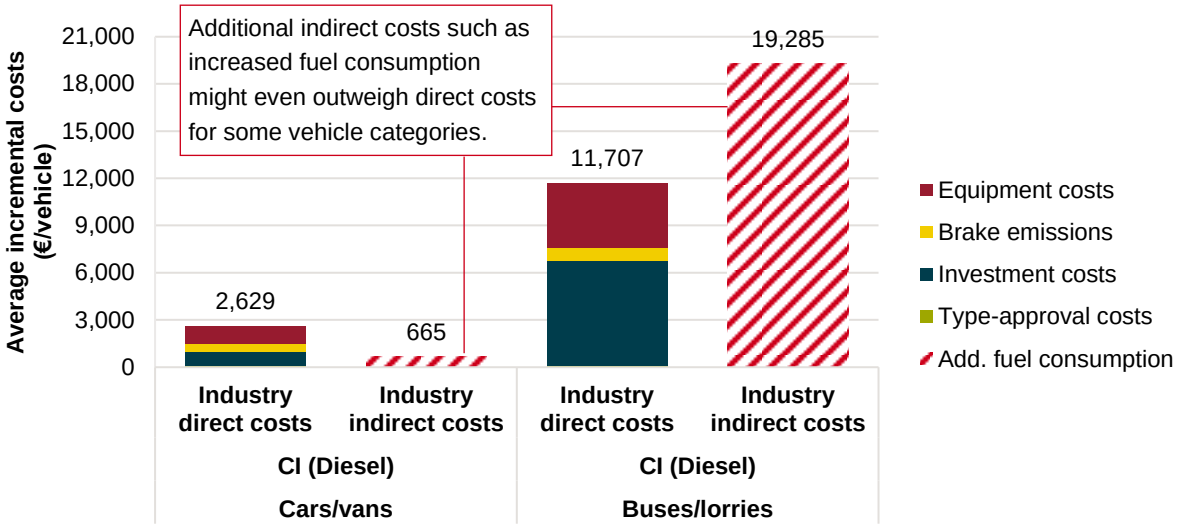
25 For instance, the Euro 7 Impact Assessment reports costs for ORVR (16 €/vehicle) on page 61 and for NAO brake pads (37.5 €/vehicle) on page 62. The underlying CLOVE study also contains cost figures for multi-gas sensors (200 €/vehicle) and OTA data transmission (40 €/vehicle) on page 289. Summing up the costs for these components yields significantly higher total costs than the reported 184 €/vehicle (including regulatory costs for exhaust emissions and costs for brake emission control).

indirect costs borne by consumers or society at large. Such indirect costs components may include (but not be limited to):

- **Limited consumer choice** – consumers of more affordable entry-level cars might face substantially higher prices than today as a result of disproportionate costs increases or even terminated production of certain models in this vehicle segment under Euro 7. As a consequence, some customers may be forced to switch to more expensive models.
- **Additional fuel consumption** – Euro 7 compliant vehicles will likely consume more fuel[26] which, in turn, will result in additional fuel costs for consumers and businesses.

The responses we have received via our questionnaire do not allow to properly quantify the implications of limited consumer choice. However, feedback from ACEA members suggests that a limitation of consumer choice caused by discontinuation of low volume or entry-level models that would otherwise need substantial and costly upgrades (with disproportionate price effects)[27] is a serious possibility for end customers.

Figure 11 Indirect costs of Euro 7: Additional lifetime fuel cost



Source: Frontier Economics based on ACEA member data

Several OEM's provided information about expected increases in fuel consumption. Based on their estimates, Euro 7 would increase fuel consumption by 3.5% on average for both, cars/vans and buses/lorries. According to the OEM's, an increase in back pressure in the exhaust system or the use of cooled exhaust gas recirculation penalising the thermodynamic cycle efficiency through pumping losses are possible drivers of this additional costs.

26 For example, more fuel will be consumed to address cold start emissions and engine/catalyst warm-up.

27 For instance, several car/van OEMs pointed out, that meeting Euro 7 would require a degree of control over the powertrain, which would require a switch to automatic transmission. Particularly, more affordable vehicles are expected to phase out – effectively limiting consumer's choice.

We approximated additional fuel costs over the lifetime of a Euro 7 vehicle, the assumptions summarised in Annex B. Based on our simplified calculation, we estimate **additional fuel costs** for **cars/vans of around 650 € per vehicle** and for **long-haul trucks up to 20,000 € over the entire lifetime of the vehicle** (see Figure 11). Please note that these values are undiscounted and based on historical fuel prices which we assume to stay constant. Considering that final fuel prices for consumers are expected to increase in the next couple of years[28] and that additional AdBlue consumption is not taken into account, our figures are rather a conservative estimate.

[28] This is driven by an expected rise of oil prices (see for example the World Energy Outlook (2020) in the stated policies scenario) and higher taxes on fossil fuels. An increasing shift to e-fuels would also cause higher fuel costs from today's perspective.

Annex A – Details on the questionnaire

All cost figures in this paper are derived from cost estimates provided by industry members through a questionnaire designed by Frontier. In this section we provide further details on:

- Vehicle categories for which we differentiate cost estimates,
- Cost categories which make up our total cost estimate,
- Open questions which we ask in addition to cost estimates.

Vehicle categories

For the purpose of this survey, we distinguish between different vehicle categories based on vehicle size and other technical attributes. Similarly to the approach taken by the EC in its Impact Assessment, we group vehicles into **three vehicle categories**:

- **Cars/vans** – encompasses low-duty vehicles (LDV) typically used for passenger transport. Under the UNECE vehicle classification system[29], M1 and N1 vehicles would fall into this category.
- **Buses** – we include large vehicles for mass transportation of passengers (i.e. more than eight seats) in this class. This includes both M2 and M3 vehicles.
- **Lorries** – heavy-duty vehicles (HDV) carrying large volumes of goods are grouped in this class. N2 and N3 vehicles (exceeding 3.5 tonnes) are grouped in this class.

The broader vehicle classes above are further subdivided into different **engine types** based on the vehicle's fuel technology:

- **PI (Petrol engines)** – we only apply this engine type to our cars/vans class. We decided to exclude it for larger HDVs (buses/lorries) as Petrol engines make up a negligible share of the European market for these vehicles.
- **CI (Diesel engines)** – this engine type applies to all of our vehicle classes.
- **BEV (battery-electric vehicles)** – includes vehicles powered by electric batteries rather than combustion engines. This engine type applies to all of our vehicle classes.

Within in each class and engine type we differentiated further between **vehicle segments** which reflect different ratios of engine power to vehicle mass. We have chosen two different approaches to our segmentation for cars/vans as well as for buses/lorries.

- To ensure comparability, we closely follow the segmentation used by the EC in its Euro 7 Impact Assessment for our **cars/vans** class.[30]

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29 For further detail see: https://alternative-fuels-observatory.ec.europa.eu/general-information/vehicle-types

30 This segmentation, in turn, is based on an ICCT report and aggregates the segments used there into larger groups.[30] Similarly to the Impact Assessment, we distinguish between **small, medium and large segments**. We group the ICCT's

- For **buses/lorries** we use a segmentation by vehicle mass based on the UNECE vehicle classes. For these categories of vehicles we only distinguish between **small and large segments.** Small buses include M2 vehicles (with a mass of up to 5 tonnes) while large buses are M3 vehicles (exceeding 5 tonnes). Similarly, small lorries consist of N2 vehicles (up to 12 tonnes) and large lorries of N3 vehicles.

Cost categories

In our analysis, we distinguish between direct costs – on which this survey mainly focuses[31] – and indirect costs of the Euro 7 norm. Under **direct costs** we group any incremental costs for the manufacturer that are incurred in the production of Euro 7 compliant vehicles. Please note that the direct costs we estimate are not necessarily reflective of prices paid by consumers as they exclude the margins on top of production costs. Therefore, the increase of consumer prices would likely be higher than our incremental cost estimates.

As **indirect costs** we understand those costs that may affect consumers or society at large outside of the direct effect on vehicle prices (which we do not estimate here). Examples of indirect costs may include (but are not limited to):

- Costs of **increased fuel consumption** – potential Euro 7 compliant vehicles are expected to consume more fuel for a variety of reasons[32] which will result in higher fuel costs for consumers. We have calculated an approximate estimate for average additional costs for each vehicle class borne by customers over the lifetime of a Euro 7 vehicle based on industry expectations for the average increase in fuel consumption (see page 14).
- Costs arising from **limited consumer choice** – If compliance with Euro 7 will require costly upgrades to hardware components, the production and sale of certain car segments may no longer be economically viable. More affordable entry-level vehicle models will see proportionately larger cost (and price) increases. These vehicles are more at risk of being discontinued in favour of high-end models which may already be equipped with some of the necessary components or for which additional equipment would have relatively smaller cost impact. In this survey, we have not attempted to quantify these potential costs.

Direct costs are broken down in different cost categories (see Figure 12) which we developed under consideration of feedback from industry experts:

"Small" and "Mini" segments into our small segment. Our medium segment includes the "Lower medium", "Medium" and "SUV/Off-road" segments. The large segment consists of the ICCT's "Upper medium", "Sport" and "Luxury" segments.

31 Whenever we refer to costs in this report without specifying whether we mean direct or indirect costs, it is implied that we are referring to direct costs.

32 Most importantly additional fuel consumed to address cold start warm-up of the engine/catalyst system.

Figure 12 Detailed direct cost categories in our questionnaire

Cost category	Description	Relevant vehicle categories
Exhaust emission control	Recurrent costs for installing components required for reducing exhaust emissions, costs related to fulfilling relevant durability requirements, this includes components such as optimised coated GPF, anti-spit back/vapour valves, high flow purge valves, pump or OBD leak checks, OTA data transmission, etc.	PI and CI vehicles
Evaporative emission control and ORVR	Recurrent costs for installing components required for reducing evap. emissions, recurrent costs for installing onboard refuelling vapour recovery systems (ORVR), costs related to fulfilling relevant durability requirements	PI (petrol) vehicles
Onboard emission monitoring (OBM)	Recurrent costs for installing sensor technology required for continuous on-board emission monitoring (OBM), this component is specifically required in the Impact Assessment's Policy Option 3a	PI and CI vehicles
Battery durability	Recurrent costs related to fulfilling battery durability requirements (applies only to BEVs)	BEVs
Brake emission control	Recurrent costs for installing components required for reducing brake emissions	All vehicles
Investment costs	Aggregated costs for investments in research & development of new technologies or upgrades to existing systems, investments in new facilities, costs for tooling at suppliers'/own facilities, logistics, etc.	All vehicles
Type-approval costs	Recurrent costs for testing and calibrating technologies for new vehicle models, costs for testing and witnessing in the context of type-approval, fees for granting type-approval paid to authorities, costs for reporting and to fulfil other information provision obligations	All vehicles

Source: Frontier Economics

Open questions

We also asked OEMs **open questions** with the aim to gather **information related to indirect costs** of Euro 7. In particular, we were interested about industry expectations for the level of additional fuel consumption – which we used in our estimation of additional lifetime fuel costs for consumers – and for potential cost increases due to limitation of consumer choice.[33]

[33] However, we did not receive sufficient information on this issue to analyse it quantitively.

Annex B – Details on the indirect cost estimation

Figure 13 Assumptions for the indirect cost estimations of the additional fuel consumption

Parameter	Value [unit]	Source
Additional fuel consumption of Euro 7	■ 3.5 [%] for cars/vans ■ 3.5 [%] for buses/lorries	Questionnaire
Vehicle lifetime	■ 200,000 [km] for cars/vans ■ 1,116,000 [km] for buses/ lorries	■ EC's proposal for a new Euro 7 regulation from November 10, 2022 (table 2 for option PO3a, p. 27/28) ■ Impact Assessment for CO_2 Standards (p. 149) defines lifetime as mileage equal to that of 10 years of driving with the mileage specified for the specific vehicle and use case in the Regulation (EU) 2019/1242 (table 4) for the subgroup 5 Long-Haul vehicle: 10 a * 116,000 km/a
Average fuel consumption of Euro 7 vehicle	■ 5 [l/100km] for cars/vans ■ 25 [l/100km] for buses/lorries	Own rough approximation assuming an about 20 % lower consumption as today's average fuel consumption for the corresponding segments
Fuel price	■ 1.9 [€/l] for petrol/diesel	EC Weekly Oil Bulletin (average of weekly data for Apr22-May23)

Source: Frontier Economics

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