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PART 1/2

**COMMISSION STAFF WORKING DOCUMENT**

**IMPACT ASSESSMENT**

*Accompanying the document*

**Proposal for a Regulation of the European Parliament and of the Council  
setting CO<sub>2</sub> emission performance standards for new heavy duty vehicles**

{COM(2018) 284 final} - {SEC(2018) 233 final} - {SWD(2018) 186 final}

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## GLOSSARY - ACRONYMS AND DEFINITIONS

ACEA	Federation of European Car Manufacturers
CNG	Compressed Natural Gas
CO <sub>2</sub>	Carbon dioxide
EEA	European Environment Agency
ESR	Effort Sharing Regulation
ETS	EU Emission Trading System
EURO VI	Euro VI emission standard for HDV as regards air pollutants, which are set out in Regulation (EC) 595/2009
GDP	Gross Domestic Product
GHG	Greenhouse gas(es)
GVW	Gross Vehicle Weight –weight of the fully loaded vehicle and/or trailer, including all cargo, fluids, passengers and optional equipment
HDV	Heavy-Duty Vehicles: freight vehicles of more than 3.5 tonnes (lorries) or passenger transport vehicles of more than 8 seats (buses and coaches)
IEA	International Energy Agency
Mission Profile	A trip with certain characteristics in terms of length, slope and speed used for the purpose of VECTO simulations
LCV	Light Commercial Vehicle(s): van(s)
LDV	Light-Duty Vehicle(s): passenger cars and vans
LEV	Low-Emission Vehicles: vehicles with tailpipe emissions significantly below the fleet-wide average emissions
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NGO	Non-Governmental Organisation
NO <sub>x</sub>	Nitrogen oxides (nitric oxide (NO) and nitrogen dioxide (NO <sub>2</sub> ))
OEM	Original Equipment Manufacturer (HDV manufacturer)
Payload	Weight that a vehicle can carry
Trailer	A road vehicle for transporting goods designed to be hauled by a road transport vehicle
VECTO	Vehicle Energy Consumption calculation Tool
ZEV	Zero-emission vehicles: vehicles with zero tailpipe emissions

## 1 INTRODUCTION

### 1.1 Policy context

Under the Paris Agreement, the European Union (EU) has committed to avoiding dangerous climate change by limiting global warming to well below 2°C. Decreasing greenhouse gas (GHG) emissions is a key prerequisite for fulfilling that commitment. The EU 2030 framework for climate and energy includes a target of at least 40% reduction of domestic EU GHG emissions compared to 1990 levels. The emission reductions in the Emissions Trading System (ETS) and in the sectors covered by the Effort Sharing Regulation (ESR) amount to at least 43% and 30% by 2030 compared to 2005, respectively.

Road transport, a sector covered by the ESR, is of key importance for reducing GHG emissions and decarbonising the EU economy. In the past 25 years however, as demand for mobility grew, transport emissions have steadily increased to reach 22% of EU GHG emissions in 2015.

While Heavy Duty Vehicles (HDVs) are currently responsible for about a quarter of CO<sub>2</sub> emissions from road transport in the EU and for some 6% of total EU emissions, their CO<sub>2</sub> emissions are not yet regulated in the EU. The Commission has taken a number of preparatory initiatives in this direction over the past years, as set out in Section 1.4.

This initiative is part of the 2018 third Mobility Package and builds on the 2016 Low Emission Mobility Strategy, the previous two Mobility Packages, the Industrial Policy Strategy (see Annex 6) and the Commission proposal for CO<sub>2</sub> emission standards post-2020 for cars and vans<sup>1</sup>.

### 1.2 Description of the Heavy Duty Vehicles (HDV) sector

HDVs are defined as freight vehicles of more than 3.5 tonnes (lorries) or passenger transport vehicles of more than 8 seats (buses and coaches).

Road freight transport is essential for the development of trade and commerce on the European continent. Lorries carry 71.3% of freight transported over land<sup>2</sup>, delivering also essential public services such as garbage collection, fire and construction. The road freight and passenger transport sector largely consists of SMEs, with over 600,000 enterprises across the EU employing almost 3 million people. Another 3.5 million people are employed in lorry manufacturing, repair, sales, leasing and insurance<sup>3</sup>.

The production of HDVs<sup>4</sup> in the EU is concentrated in a few countries, in particular Germany, the Netherlands, Belgium, France, Sweden and Spain (Figure 1). The EU is a major exporter of lorries, which generates a trade balance surplus of €4.9 billion in 2016.

Six major manufacturers dominate the EU lorry market: Daimler, DAF, M.A.N., Scania, Renault, Volvo and Iveco<sup>5</sup>, as shown in Figure 2. The Chinese and Asia-Pacific markets are less consolidated and dominated mainly by domestic manufacturers (see Annex 5.1).

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<sup>1</sup> COM (2017) 676 final

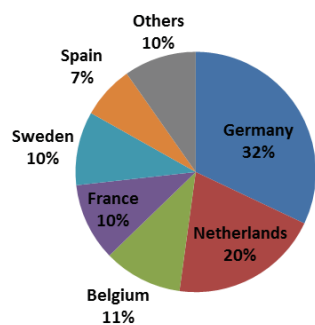
<sup>2</sup> European Commission (2017), EU transport in figures – statistical pocketbook 2017, [https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017\\_en](https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en)

<sup>3</sup> International Road Transport Union: <https://www.iru.org/who-we-are/about-mobility/trucks>

<sup>4</sup> Data refers to HDVs over 15 tonnes (including articulated trucks).

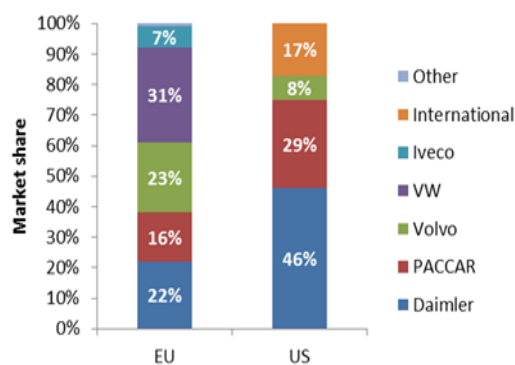
<sup>5</sup> DAF is owned by US manufacturer PACCAR. Renault Trucks is part of the Volvo Group, while M.A.N. and Scania are owned by Volkswagen.

**Figure 1: HDV production (2016) in the EU by Member State<sup>6</sup>**



Source: ACEA Pocket Guide 2017/2018

**Figure 2: 2014 Market Share of tractor lorry manufacturers in the EU and US**



Source: ICCT (2015)

### 1.3 Specificities of the HDV sector compared to light-duty vehicles (cars and vans)

CO<sub>2</sub> emissions from new light-duty vehicles (LDVs) have been regulated in the EU for a number of years. While several elements of the overall approach used for regulating cars and vans will be considered, the regulatory experience cannot be simply carried over to HDVs. This is because the HDV market is significantly different, in particular due to the wider range of types and models of vehicles, the lack of certified data as well as the size and the market structure, with purchasers of HDVs mostly consisting of SMEs. Also, HDV purchase prices are on average around 110,000 EUR per lorry, and thus far higher than for LDVs. The mileages driven by HDVs are on average around 1,200,000 km, and exceed those of LDVs by about a factor of 6. These key differences, which are summarised in Annex 5.2, need to be taken into account when preparing policies regulating CO<sub>2</sub> emissions from HDVs.

### 1.4 VECTO, certification and monitoring/reporting of HDV CO<sub>2</sub> emissions

In 2014, the first key Commission initiative to tackle HDV CO<sub>2</sub> emissions in the EU was the adoption of a strategy for reducing HDVs fuel consumption and CO<sub>2</sub> emissions<sup>7</sup>. This strategy laid down a step-wise approach for regulating CO<sub>2</sub> emissions in this sector, which has been rolled out as follows:

- i. Firstly, the pre-requisite was to develop a tool for determining CO<sub>2</sub> emissions and fuel consumption of HDVs in a harmonized way across the EU. For that purpose, the Commission has engaged since 2009 with main stakeholders in the development of a simulation tool, the so-called the Vehicle Energy Consumption Calculation Tool (VECTO).
- ii. Secondly, the Commission adopted the Certification Regulation<sup>8</sup>. This Regulation requires HDV manufacturers, as of 1 January 2019, to determine the CO<sub>2</sub> emissions and fuel consumption of new vehicles they place on the EU market. The CO<sub>2</sub> emissions are calculated by using VECTO. Information on the CO<sub>2</sub> emissions and fuel consumption of new HDVs will be declared for the registration of vehicles under the EU type-approval legislative framework.

<sup>6</sup> Data refers to HDVs over 15 tonnes (including articulated trucks).

<sup>7</sup> COM(2014) 285 final

<sup>8</sup> Regulation (EU) 2017/2400

- iii. Thirdly, the Commission adopted in May 2017, as part of the first mobility package, a proposal<sup>9</sup> for a Regulation on the monitoring and reporting of CO<sub>2</sub> emission and fuel consumption data (“Monitoring and Reporting Regulation”). The European Parliament and the Council reached an agreement in March 2018 on this proposal. Monitoring and Reporting Regulation requires that HDV manufacturers monitor and report these data to the Commission to be made publicly available.

As a result of these important steps, information on emissions data and fuel consumption will be improved making the comparison of the performance of vehicles possible. These steps were also pre-conditions for regulating CO<sub>2</sub> emissions from this sector.

As regards the scope of the legislation, to date the Certification Regulation covers the four main groups of lorries, accounting for about 65% to 70% of total HDV CO<sub>2</sub> emissions. Annually, some 250,000 new lorries falling into these four groups are registered. Buses and coaches, which are not yet covered by the Certification Regulation, represent about 10% of the total HDV CO<sub>2</sub> emissions.

The extension of the Certification Regulation to other groups of HDVs requires the further development of the VECTO simulation tool. At this stage, VECTO can simulate only lorries above 7.5 tonnes. Further development work is ongoing for VECTO to cover additional new technologies as of 2020 and to simulate smaller lorries, as well as buses and coaches as of 2020, and trailers as of 2021.

Additional information can be found in Annex 8.

## **1.5 Legal context**

No EU legislation regulates directly the level of CO<sub>2</sub> emissions of HDVs. Legislation indirectly affecting CO<sub>2</sub> emissions from HDVs is listed in Annex 6.

## **1.6 Evaluation of the implementation**

No evaluation could be carried out in view of the absence of EU legislation setting CO<sub>2</sub> standards for HDVs.

Nevertheless the relevant experiences from the first years of implementing the legislation setting CO<sub>2</sub> emission performance standards for light-duty vehicles<sup>10</sup> have been taken into account for this Impact Assessment. This is in particular the case for the main governance related issue identified during that evaluation with the recommendation to systematically monitoring the evolution of the gap between the type-approval emissions and those in the real world as can be seen from Section 5.5.

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<sup>9</sup> COM(2017) 0279 final

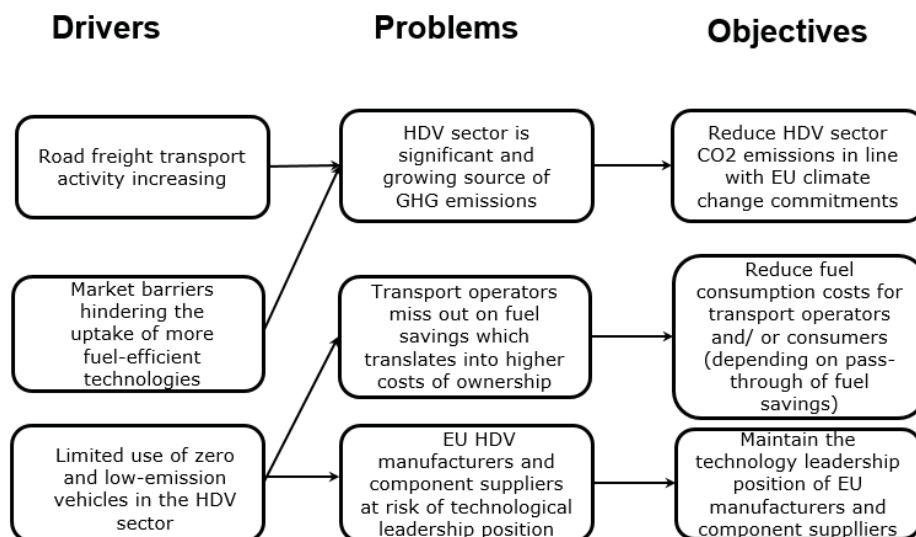
<sup>10</sup> Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO<sub>2</sub> emissions from light-duty vehicles, available at: [https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation\\_ldv\\_co2\\_regs\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf)

## 2 PROBLEM DEFINITION

### 2.1 What are the problems?

An overview of the drivers, problems and objectives is presented in Figure 3.

**Figure 3: Drivers, problems and objectives**



#### 2.1.1 Problem 1: HDV sector is a significant and growing source of GHG emissions

In 2015, GHG emissions from HDVs were around 19% higher than in 1990, representing around 6% of total EU emissions, and almost a fifth of all transport emissions. Without further action and HDV activity steadily increasing, HDV CO<sub>2</sub> emissions are set to increase by up to 6% between 2015 and 2030.<sup>11</sup>

At the same time, the EU has set ambitious targets for reducing GHG emissions by 2030, including for the non-ETS sectors, to which the transport sector must contribute. Cars and vans are already delivering their share and legislation has been proposed<sup>12</sup> so that they continue doing so after 2020. However, the accompanying Impact Assessment<sup>13</sup> shows that further measures are needed in the road transport sector, including for HDVs, in order to cost-effectively contribute to meet the 2030 national targets set under the Effort Sharing Regulation<sup>14</sup>.

To this end, a similar bottom-up approach will be used in this Impact Assessment as was the case for the Impact Assessment underlying the Cars and Vans CO<sub>2</sub> proposal, i.e. assessing the impacts of different options covering a broad range of target levels for new lorries (see Section 5.1.4).

As a result, for each target level, the GHG emission reductions that would be achieved over the next decade can be determined and hence the contribution to the reduction of GHG

<sup>11</sup> SWD(2017) 180 final

<sup>12</sup> COM (2017) 676 final

<sup>13</sup> SWD (2017) 650 final

<sup>14</sup> As regards GHGs, this Impact Assessment focuses on CO<sub>2</sub> emissions. Emissions of other GHGs, such as methane and nitrous oxide are dealt with in Regulation 595/2009 on type-approval of motor vehicles and engines with respect to emissions from HDVs (Euro VI).

emissions needed to meet the 2030 targets, as well as the related economic costs and benefits (see Section 6.2.4.2, Section 6.2.4.4.4 and in Annex 10.9).

As regards air pollutants, transport remains the largest contributor to NO<sub>x</sub> emissions in the EU. High levels of air pollution are of particular concern in urban areas. Even though HDVs are subject to the EURO standards for pollutant emissions and drive for most of their mileage in intra-urban areas, their emissions contribute both to background and traffic NO<sub>2</sub> concentrations. Contribution of HDVs to total NO<sub>x</sub> emissions can be nearly 40 %<sup>15</sup>, with a roughly equal split between buses, coaches and heavy goods vehicles.

### 2.1.2 Problem 2: Transport operators and their customers miss out on possible fuel savings due to the limited uptake of fuel-efficient technologies

A broad range of technologies for reducing the fuel consumptions and CO<sub>2</sub> emissions from HDVs is readily available on the market, while others are at various stages of development. Furthermore, HDVs may be equipped with alternative powertrains such as LNG fuelled engines.

Table 1 groups these technologies into five types depending on their nature, degree of implementation and constraints affecting their widespread deployment. Technologies listed in the first and second category are readily available while the timing of roll-out, commercial availability and up-take of the others is more uncertain.

For technologies of the first type, no technical or legal constraints should prevent their widespread deployment. Table 1 shows the costs and fuel savings for a number of these readily available technologies when applied for a long-haul tractor vehicle<sup>16</sup>, as well as their current market penetration in the EU.

Surprisingly, as illustrated in Figure 4, many of these technologies are not yet widely spread even though their costs are low – generally well below 1% of the purchase price of a new vehicle - and they would bring considerable net savings over time. However, the net savings of individual technologies will be perceived as rather modest if compared to the total fuel bill, as most of them do not save more than 2% of the fuel bill or about 0.5% of the total operating costs. If transport operators want to reap the full benefits, they will have to select a number of technologies at the same time, which makes the purchasing decision more complex.

Similar conclusions have been drawn up by the US authorities in their Regulatory Impact Analysis<sup>17</sup> underpinning the phase 2 of the US legislation setting CO<sub>2</sub> emission standards for HDVs: *"Economic theory suggests that interactions between vehicle buyers and sellers in a normally-functioning competitive market would lead HDV manufacturers to incorporate all technologies that contribute to lower net costs into the vehicles they offer, and buyers to purchase them willingly. Nevertheless, many readily available technologies that appear to offer cost-effective increases in HDV fuel efficiency (when evaluated over their expected lifetimes using conventional discount rates) have not been widely adopted, despite their potential to repay buyers' initial investments rapidly."*

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<sup>15</sup> UK Air Quality plan 2017 – HDV share is 36%. Berlin Air Quality Plan 2011-2017 – HDV share is 35%

<sup>16</sup> A tractor with a 4x2 axle configuration and a technically permissible laden mass of more than 16 tonnes (vehicle group 5), which is used for long haul (LH) transport (see Annex 8.2)

<sup>17</sup> US EPA and NHTSA (2016) Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium and Heavy Duty Engines and Vehicles - Phase 2: Regulatory Impact Analysis (<https://nepis.epa.gov/Exe/ZyPDF.cgi/P100P7NS.PDF?Dockey=P100P7NS.PDF>)



The lack of uptake is to the detriment of freight transport operators, who on average experience fuel costs about a quarter of their total operational costs<sup>18</sup>. A higher uptake of efficient technologies should in particular benefit the more than half a million transport companies in the EU that are SMEs or micro-enterprises and work off tight margins.

The uptake of the technologies of the second type shown in Table 1 has been constrained by legal restrictions, which will be removed in the near future.

Based on the analysis of the technologies and fuel savings potentials, it appears that the full deployment into the fleet of the first two types of technologies listed in Table 1 would bring about 15 to 20% CO<sub>2</sub> emission savings in 2025 compared to 2019.

As regards the technologies in the other three groups, their broad uptake is currently constrained either by the fact that there are at present only prototypes available and mass production has not yet started (type 3) or by external technical factors including the availability of the necessary infrastructure, e.g. refuelling, recharging, catenary lines. However, each of them has the economic potential to be taken up over the next decade.

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<sup>18</sup> SWD (2017) 188, section 5.6 and Annex 10, Figure 18.

**Table 1: Overview of technologies for reducing CO<sub>2</sub> emissions from HDV, their current and future market penetration, and constraints for their widespread deployment**<sup>19</sup>

Technology types	Description	Market penetration	Constraints
<b>1. Readily available technologies</b>	Technologies readily available that could be implemented across the whole fleet. Examples: low rolling resistance tyres, better lubricants, certain aerodynamic improvements or efficiency improvements of the engine and the pollutant after-treatment systems.	Current market penetration is limited despite high net savings	None
<b>2. Available technologies, which are not implemented due to legal restrictions</b>	Technologies currently available from a technical perspective, but not implemented due to legal restrictions Examples: elongated cabins, rear-view cameras instead of mirrors.	Currently no market penetration. Implementation expected as of early 2020s.	Constraints due to type approval and safety legislation and the Weights and Dimensions Directive. These are to be removed through Commission proposals as part of the 3 <sup>rd</sup> Mobility Package amending the General Safety Regulation and the Weights and Dimensions Directive. Amendments will also be necessary to implementing type approval legislation until end 2018.
<b>3. Prospective technologies</b>	Known technologies, existing at least as prototypes or currently installed on some selected vehicles. However, due to their complexity and a certain lack of maturity, a deployment on a wide range of the vehicle fleet by 2025 may be very difficult to achieve. Examples: waste heat recovery or hybridisation.	Currently almost no market penetration Based on existing development cycles of manufacturers, the uptake rates of these technologies in the year 2025 will still be limited (max. 5% for waste heat recovery and full hybridisation)	No principal technical constraints. Constraints from integrating the necessary development work into existing product cycles.
<b>4. LNG vehicles</b>	Current "conventional" LNG technology offers a CO <sub>2</sub> emission reduction of up to 5% as compared to similar diesel vehicles. A new LNG technology is under development and could achieve up to 20% fuel efficiency improvement when operated in the high-pressure direct injection (HPDI) engine cycle.	Currently very limited market penetration (<1% of the fleet). Contribution of conventional LNG vehicles in 2025 is expected to be limited. For the following years, the contribution of LNG vehicles can be larger depending on the CO <sub>2</sub> emission target levels. The most efficient HDPI LNG vehicles are expected to be available on a wide scale only after 2025.	The use of LNG vehicles is constrained by the required LNG infrastructure, which is expected to improve over time.
<b>5. Zero- and low-emission vehicles</b>	Battery and fuel cell electric lorries are in pilot or early development stages. Pilot project for lorries using catenary lines; no commercial concept of large plug-in hybrid lorries.	Currently no market penetration (see Section 5.3). Future market penetration depends on the CO <sub>2</sub> emission target levels and possible incentives.	The use of zero and low emission vehicles is constrained by the required appropriate infrastructure.

<sup>19</sup> "Heavy Duty Vehicles - support for preparation of impact assessment for CO<sub>2</sub>", study for the Commission by TNO and consortium, report to be published

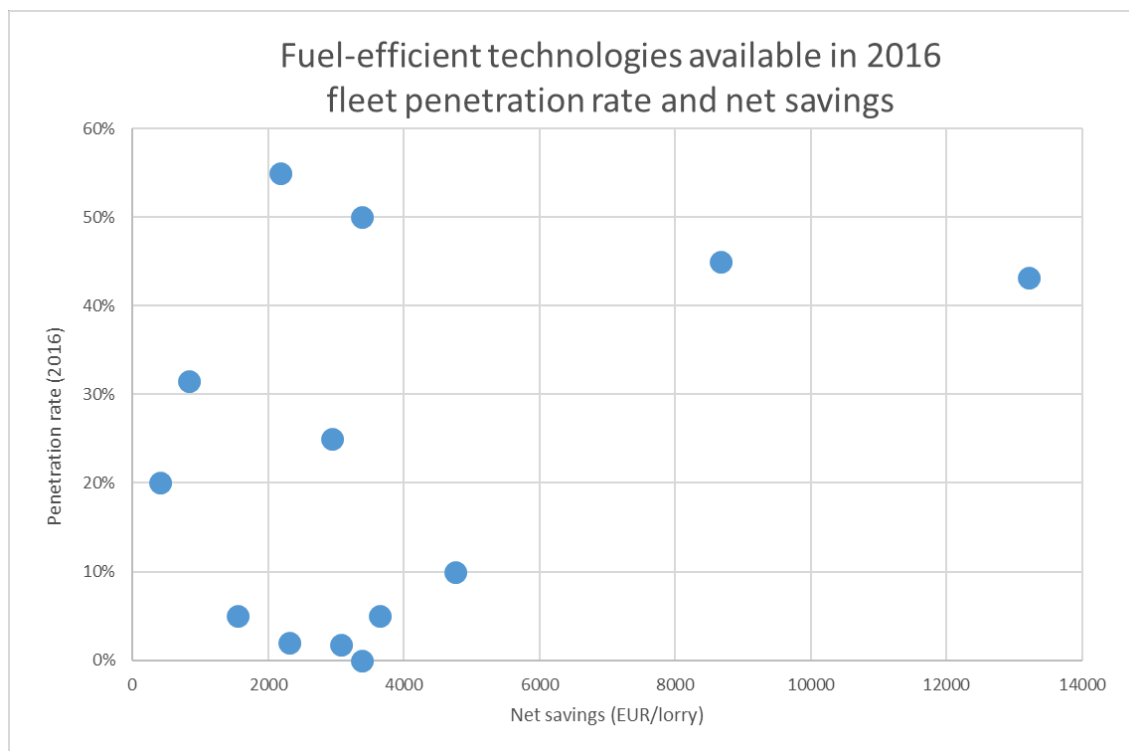
**Table 2: Cumulative fuel savings during first use (5 years)<sup>20</sup> and manufacturing costs of a series of readily available technologies, listed under the first technology type in Table 1, for reducing CO<sub>2</sub> emissions from HDV, and their implementation rate in 2016**

Technologies	Fuel savings	Technology costs		Net savings		Payback period in years	Implementation rate
	(1)	(2)	(3)	(4)	(5)		
Improved lubricants	€1,910	€23	0.02%	€1,887	1.1%	0.1	2%
Improved SCR and optimised SCR heating methods	€3,979	€105	0.10%	€3,874	2.2%	0.1	10%
Aerodynamic mud flaps	€2,880	€135	0.12%	€2,745	1.6%	0.2	0%
Tire pressure monitoring systems (TPMS) on truck	€459	€149	0.14%	€310	0.2%	1.3	20%
Closable front grille	€2,531	€150	0.14%	€2,381	1.3%	0.2	25%
Cooling fan	€825	€180	0.16%	€645	0.4%	0.9	31%
Friction reduction + improved water and oil pumps	€3,148	€200	0.18%	€2,948	1.7%	0.3	5%
Air compressor	€2,728	€250	0.23%	€2,478	1.4%	0.4	2%
Reduced losses (lubricants, design)	€2,978	€250	0.23%	€2,728	1.5%	0.3	50%
Predictive cruise control (PCC)	€2,282	€600	0.55%	€1,682	1.0%	1.1	55%
Downspeeding with optimised map	€1,170	€750	0.68%	€420	0.2%	2.6	15%
Improved turbocharging and EGR	€7,958	€1,050	0.95%	€6,908	3.9%	0.5	45%
Side and underbody panels at truck chassis	€2,531	€1,539	1.40%	€992	0.6%	2.5	5%
Low rolling resistance tires on truck/tractor	€12,541	€2,100	1.91%	€10,441	5.9%	0.7	43%

- (1) Fuel savings from a first use (5 years) perspective (EUR/lorry)
- (2) Average technology costs (EUR/lorry) – based on a study carried by Commission contractors
- (3) Technology costs (percentage of vehicle purchase price, i.e. €110,000)
- (4) Net savings (EUR/lorry) from a first use (5 years) perspective: difference between (1) fuel savings and (3) technology costs
- (5) Net savings from a first use (5 years) perspective (percentage of total fuel costs)
- (6) Payback period of technology costs in years
- (7) Technology implementation rate across the EU fleet in 2016

<sup>20</sup> Costs and savings for a tractor with a 4x2 axle configuration and a technically permissible laden mass of more than 16 tonnes (vehicle group 5), used for long haul (LH) transport (see Annex 8.2)

**Figure 4: Penetration rate of some readily available technologies and the net savings they deliver (first use (5 years) perspective)**



*2.1.3 Problem 3: EU HDV manufacturers and component suppliers are at risk of losing their technological and innovation leadership position*

The focus of this problem is on the risk of lagging behind in terms of innovation in new technologies.

The EU HDV manufacturers and component suppliers currently have a global technological leadership position, as EU lorries are more fuel efficient than lorries in other economies. However, EU manufacturers face increasing global competitive pressures. Significant markets such as the US, Canada, Japan and China have in recent years implemented fuel consumption and/or emission standards in order to stimulate innovation and rapidly improve vehicle efficiency. Annex 5.3 provides an overview of the legislation and Annex 7.2 gives data on average fuel consumption.

On the one hand, the EU could benefit, via spill-over effects, from this evolution, as it will create technological progress and economies of scale in the rest of the world. On the other hand, this would potentially increase the chance that, in absence of policy incentives, manufacturers would market the least efficient HDVs in Europe, while keeping more efficient technologies in markets with regulations to curb emissions.

In view of this, the EU HDV manufacturers and component suppliers would need to keep up with the technological improvements in the other markets in which they are active, in order to preserve their leading innovative position.

This pressure is already clearly visible in the field of electric buses and smaller trucks where Chinese manufacturers have taken a significant technological leadership. In China, more than 300,000 electric buses are already in circulation, compared to about 1,000 vehicles in the EU. This development in China is mainly forced by public tendering also trying to tackle severe problems of air pollution in cities.

Since European manufacturers are hardly present in the Chinese bus market, they could easily lose competitive edge for electric HDVs in general if those are introduced too slowly or in insufficient numbers in Europe.

Thus, the future competitive position of EU manufacturers and suppliers operating globally would be strengthened with respect to competitors of other regions if in their home market they provide, by default, vehicles with high standards.

From a longer-term perspective, the absence of regulatory pressure for innovating and improving HDV fuel efficiency in the EU could potentially risk putting manufacturers only present in the European markets at a disadvantage with respect to better prepared competitors from other regions.

Experience with the cars and vans CO<sub>2</sub> legislation shows that CO<sub>2</sub> emission standards are a strong driver for innovation. The lack of such regulatory approach in the EU with regards to CO<sub>2</sub> emissions from HDVs is therefore a factor of risk for the EU industry to lose their leadership on innovation.

## **2.2 What are the problem drivers?**

### *2.2.1 Driver 1: Road freight transport activity is increasing*

The road freight sector must accommodate the increasing demand for the movement of goods on the EU's road networks. As a result, road freight transport by HDVs has had the most steady growth and increasingly high relative share among the main transport modes. Despite the economic and financial crisis in 2007 - 2009, road freight activity was 34% higher in 2015 compared its 1995 levels.

In the longer term, under current trends and adopted policies<sup>21</sup>, road freight transport activity is set to increase between 2010 and 2050 by about 56% (1.1% p.a.) due to a strong correlation with economic growth (see Annex 7.3).

### *2.2.2 Driver 2: Barriers hindering the uptake of more fuel-efficient technologies*

In a perfectly competitive market, with perfect information, HDV manufacturers would provide mostly vehicles equipped with advanced fuel-efficient technologies leading to net savings, while most buyers would be willing to purchase such vehicles. However, as shown in Section 2.1.2, a large number of readily available cost-effective technologies are not widely deployed in the market, even though they could bring high net savings from a first use perspective.

As fuel costs are a major item in transport operators' expenses, one would expect fuel efficiency considerations to be among their key criteria in purchasing a new vehicle.

Most transport operators work off a payback period of maximum three years, which is less than the average period of use by the first buyer and far below the average lifetime of the vehicle. This is a sign that risk-aversion make some buyers of HDVs forgo opportunities that would pay off in a longer time than three years.

In the preparation of the US CO<sub>2</sub> standards for HDVs, the US EPA provided for an equivalent description of this situation, commonly known as "the energy efficiency gap"

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<sup>21</sup> SWD(2017) 180 final

or "energy paradox"<sup>22</sup>. This is due to lack of information about technology performance and network externalities that contribute to slow adoption of some technologies<sup>23</sup>.

In its regulatory impact analysis, the US authorities underlined the following: *"Explaining why the gap exists is a separate and difficult challenge from observing the existence of the gap, because of the difficulties involved in developing tests of the different possible explanations. There is very little empirical evidence on behaviors that might lead to the gap, even while there continues to be substantial evidence, via the cost and effectiveness analysis, of the gap's existence."*

According to the literature<sup>24</sup>, a number of causes may contribute to the slow adoption of some technologies, such as environmental externalities and market failures mainly related to the asymmetry of information between sellers and buyers. Based on the stakeholders' consultations, the main barriers are discussed below. This is also consistent with the analysis carried out by the US authorities in preparation of the US legislation. A study for the German government of the year 2015 came to similar conclusions for the European market<sup>25</sup>.

#### *Environmental externalities*

Even if the market was perfectly competitive and there was perfect information available to all agents, market forces would unlikely deliver the societal optimum in terms of CO<sub>2</sub> emissions. Externalities are to result from costs and benefits that are not directly priced into the market. Both transport operators and manufacturers want to maximise profits. As societal costs and benefits do not enter their calculations, supply and demand are likely to meet at a level that is not the best for the environment and climate change, see Section 6.2.4.2.1 for a calculation of the avoided cost of CO<sub>2</sub> that would result from higher use of technologies. This issue is further reinforced by imperfect information.

#### *Imperfect and asymmetric information in the new vehicle market*

Buyers of lorries have less accurate information than manufacturers about the potential performance of fuel-saving technologies. One of the main options for the buyer is to test drive the vehicle in advance or to use data from independent lorry tests. However, this would provide information only about a bundle of technologies and not on the impact of each of them. In addition, information in expert journals is limited and might not reflect the transport operators' actual usage of the vehicle.

Furthermore, transport operators often find it difficult differentiating fuel savings resulting from technology adoption. They also consider the operational measures, in particular improved driver behaviours, as more important than investments in new technologies for which the fuel efficiency gains are more difficult to evaluate. They

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<sup>22</sup> US EPA and NHTSA (2016) Greenhouse Gas Emissions and Fuel Efficiency Standards for Medium and Heavy Duty Engines and Vehicles - Phase 2: Regulatory Impact Analysis (<https://nepis.epa.gov/Exe/ZyPDF.cgi/P100P7NS.PDF?Dockkey=P100P7NS.PDF>)

<sup>23</sup> H. Klemick, E. Kopits, K. Sargent, A. Wolverson (2014) Heavy-Duty Trucking and the Energy Efficiency Paradox (<https://www.epa.gov/sites/production/files/2014-12/documents/heavy-duty-trucking-and-the-energy-efficiency-paradox.pdf>).

<sup>24</sup> D. Vernon and A. Meier (2012) Identification and quantification of principal-agent problems affecting energy efficiency investments and use decisions in the trucking industry (Energy Policy, Vol.49, October 2012, pp. 266-273) - <https://doi.org/10.1016/j.enpol.2012.06.016>

<sup>25</sup> F. Dünnebeil (ifeu), A. Kies (TUG) et al. "Zukünftige Massnahmen zur Kraftstoffeinsparung und Treibhausgasemissionen bei schweren Nutzfahrzeugen", UBA-FB-002058

might also doubt the effectiveness of fuel-saving technologies in providing benefits proportionate to their costs.

The availability of VECTO data from 2019 will help addressing asymmetries but is unlikely to be sufficient to close them. While in principle it will be possible for the prospective buyer to ask the manufacturer for information on the basis of VECTO, there is no automatism that the buyer, mostly SMEs, can acquire such comparative information on the effects of specific technologies. Access to this technical information will remain complex for SMEs and it will be difficult for buyers to make full use of the detailed reporting data<sup>26</sup>.

This point is also confirmed by the experience in the US where the availability of a simulation tool GEM has improved information but has had limited effects on the uptake of readily available technologies<sup>27</sup>.

In addition, VECTO data will only cover technologies already available in the market. The effect of new, advanced technologies will continue only to be known by manufacturers.

The price premium sellers can earn for more fuel-efficient vehicles in the second hand market is also unclear.

For these reasons of uncertainty, buyers may attach a risk premium to investing in new technologies and give a relatively larger weight to immediate costs than future savings. This will in turn affect their likelihood of adoption, and in turn the expectation of low uptake will make manufacturers less likely to bring the technologies to market. The possible scepticism from buyers towards technologies is consistent with evidence from the U.S. that “a general rule-of-thumb is to take manufacturer claims about fuel consumption reduction and cut these numbers in half”<sup>28</sup>.

The barrier on asymmetry of information also results in an '*adverse selection*' problem. Buyers are not willing to pay the price that is necessary for the seller to cover the additional technology cost with some profit margin on top. Sellers offer only packages of additional technologies only as 'premium' options<sup>29</sup>. As many buyers are under-resourced SMEs, they do not take these premium package options. This may somehow be reinforced by a widespread perception in the road freight sector that operational measures such as driver training are more beneficial compared to additional, at times expensive new technologies<sup>30</sup>. Overall, the information asymmetries and the uncertainty on the side of buyers reduce demand for new technologies and reduce the readiness of technology suppliers to invest in further research and development. The reasons for inertia in the HDV market are explored in Box 1.

#### *Access to finance*

Banks do not factor in fuel efficiency as part of their lending criteria<sup>31</sup>. As a result, higher upfront cost options are less likely to secure finance. This exacerbates the *payback gap*,

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<sup>26</sup> ECN (2018), A perspective of truck dealers on CO<sub>2</sub> emissions from trucks

<sup>27</sup> US EPA (2018). Personal communication

<sup>28</sup> ICCT (2017). Barriers to the adoption of fuel-saving technologies in the trucking sector

<sup>29</sup> George A. Akerlof, 1970. The Market for "Lemons": Quality Uncertainty and the Market Mechanism. The Quarterly Journal of Economics, Oxford University Press, vol. 84(3), pages 488-500

<sup>30</sup> CE Delft (2012) Market Barriers to Increased Efficiency in the European On-road Freight Sector. Report for ICCT.

<sup>31</sup> IRU (2017) Commercial Vehicle of the Future - A roadmap towards fully sustainable truck operations. (Report by TML) (<https://www.iru.org/sites/default/files/2017-07/iru-report-commercial-vehicle-of-the-future-en%20V2.pdf>)

i.e. the difference between the time fuel cost savings amortise the capital investment and the willingness of buyers to wait for the benefit to materialise. That adds to the explanations of the observed average payback period of three years or less.

#### *Split incentives*

Fuel consumption in the transport industry is partly affected by a principal-agent problem. There could be split incentives when the buyer of a technology is not directly responsible for the lorry's fuel costs. Two instances are:

1. Separate ownership of the lorry: the buyer of the vehicle is not its operator, for instance due to leasing arrangements. In the EU, the share of hired or leased heavy goods vehicles in total new registrations is estimated to be about 40%.
2. Fuel provisions in contracts: fuel provisions are part of fixed transport contracts such that the operator's costs do not change with fuel consumption. An EU study found that open-book fuel provisions are used by roughly 20% of the companies surveyed<sup>32</sup>.

#### *Cost pass through*

Due to the large number of transport operators, the market providing transport services is very competitive, and it is likely that a part of the fuels savings is passed through via a reduction of freight cost to the final customer of transport services. Because of that, transport operators will be uncertain to what extent purchasing a highly fuel efficient truck will translate into a higher income for them. Annex 10.8 shows that the expected magnitude of lower freight costs and increased activity is limited.

#### **Box 1: Drivers of inertia in the market for HDV**

A first driver of inertia, that prevents fuel savings technology from being adopted, is the structure of the HDV market. The current market for HDV is one where sellers offer packages of additional technologies generally as 'premium' options and not as part of standard vehicles. Apart from fuel saving technologies, these include also other technologies that improve e.g. the comfort, appearance of the vehicle. This marketing strategy allows sellers to charge more to "premium customers". As such, this marketing approach limits demand and, thus, is not likely to incentivise manufacturers to promote fuel efficiency technologies. The majority of particularly small transport operators may not be interested in buying these premium products as they have limited access to finance, and expectations of short-term pay back.

This situation is likely to persist in the existing concentrated market structure. The market is very concentrated on the side of the HDV manufacturers, which might exert low competitive pressure. The European market is dominated by only a few companies, with market shares<sup>1</sup> in the range of 7% to 30%. The relative small number of sellers might restrict product variety. In addition, the high level of price transparency in the market increases the probability of price alignment among competitors, even without explicit coordination between them. In contrast, the majority of freight operators are small businesses, with 85 % having fewer than 10 vehicles<sup>33</sup>.

<sup>32</sup> CE Delft (2012) Market Barriers to Increased Efficiency in the European On-road Freight Sector. Report for ICCT.

<sup>33</sup> Hill N, Finnegan S, Norris J et al (2011) Reduction and testing of greenhouse gas (GHG) emissions from heavy-duty vehicles Lot 1: strategy, AEA, Didcot, United Kingdom.



A second driver is the presence of market uncertainties. Transport operators have difficulties in objectively assessing the fuel savings of the large variety of fuel efficient technologies. The net savings of these technologies will often be perceived as rather modest in the order of 0.5% of total operating costs. More substantial savings will only be made if a number of technologies is purchased at the same time. In addition, high time preferences make some buyers of lorries forgo opportunities that would pay off in a longer time than three years. Other considerations are the widespread perception of transport operators that operational measures such as driver training are sufficient, and that the first user might not be able to charge a premium when selling second-hand.

### 2.2.3 Driver 3: Limited use of zero and low-emission vehicles in the HDV sector

HDVs rely for about 98% on the use of diesel fuel. Currently, there are virtually no zero- or low-emission lorries on the European roads in the vehicle groups targeted by this Impact Assessment. However, almost all traditional manufacturers have announced plans for electrification. Some new manufacturers from outside the EU, such as BYD and Tesla, aim to produce exclusively electric HDVs and want to enter the European market.

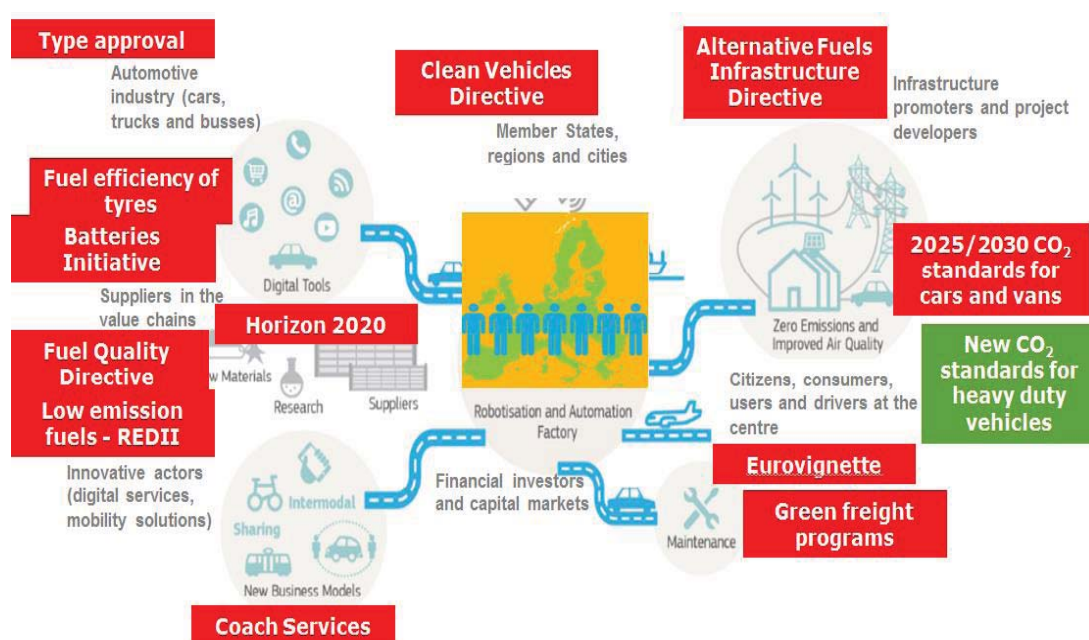
In some other HDV groups, such as buses or smaller lorries, ZEV/LEV development and uptake is more advanced and a broader range of ZEV/LEV powertrain types could be soon commercially viable.

More information on this issue can be found in Annex 9.3.

## 2.3 Overview of EU mobility policies

There are a number of different pieces of EU legislation relevant for the decarbonisation of road transport and addressing to some extent the abovementioned problems. The main regulatory and non-regulatory instruments are summarized in Figure 5 and described in Annex 6, including their expected impacts on CO<sub>2</sub> emissions. They concern supply, demand, economic and enabling instruments.

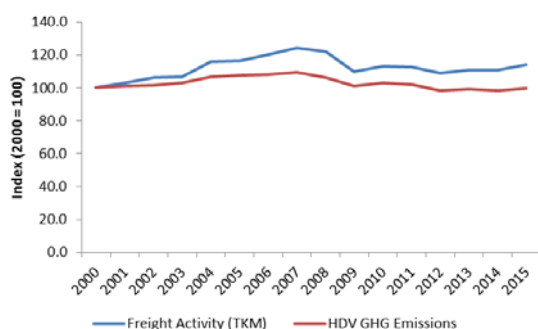
**Figure 5: Overview of main EU mobility related policies**



## 2.4 How will the problem evolve and how mobility policies affect the problem drivers?

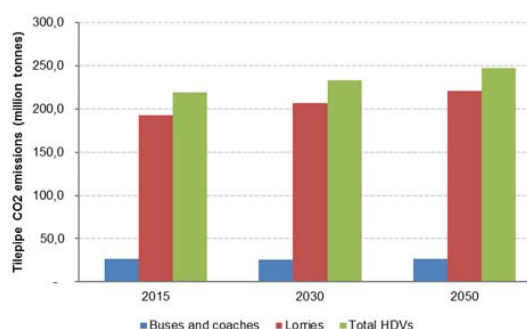
As shown in Figure 6, freight activity and GHG emissions from HDVs have been closely linked over time with very little decoupling taking place. As shown in Figure 7, without further action, HDV CO<sub>2</sub> emissions are set to increase by up to 9% between 2010 and 2030<sup>34</sup>.

**Figure 6: Trend of HDV activity versus GHG emissions**



Source: EEA and Eurostat

**Figure 7: HDV CO<sub>2</sub> emission projections 2015- 2050 without further policies**



Source: PRIMES-TREMOVE

The objective of reducing CO<sub>2</sub> emissions in the road freight transport sector can be achieved by a combination of influencing three variables, i.e. (i) reducing the level of activity, e.g. a modal shift from road to rail, improving logistics, (ii) improving the energy efficiency of road transport, and (iii) reducing the CO<sub>2</sub> intensity of energy use in transport, e.g. by increasing the percentage of low emission fuels. Since the scope of each of these three routes is limited, all three of them will be needed to achieve the EU's CO<sub>2</sub> reduction objectives and are therefore complementary. Their respective effects on CO<sub>2</sub> emission reductions are essentially cumulative.

It should also be noted that the introduction of incentives for zero- and low-emission vehicles as assessed in the draft IA would be well in line with some increased long haul freight transport via rail, as such vehicles are particularly suitable for regional freight distribution services starting from rail transport hubs.

While all existing policy measures shown in Figure 5 and detailed in Annex 6 address to a certain extent the drivers identified and complement each other, these are not sufficient for tackling the key barriers for the uptake of fuel-efficient technologies.

Annex 7 provides more details on this issue.

The energy efficiency of HDVs may improve in the period to 2030 in response to forecast higher oil prices, technology improvements, and through the implementation of related policies such as the revised Eurovignette and Clean Vehicles Directives. However, this will not be sufficient to ensure the HDV sector can contribute sufficiently towards reaching the 2030 climate change targets and the goals of the Paris Agreement.

In the absence of significant improvements in vehicle energy efficiency and the ongoing prevalence of certain barriers, transport operators will continue to miss out on operational cost savings, which also impacts transport costs.

<sup>34</sup> SWD(2017) 180 final

It should also be noted that the existence of CO<sub>2</sub> emission and fuel consumption standards in other major economies such as Japan, the US, Canada and China spurs the development of more energy-efficient technologies in their HDV sectors. Without any regulatory pressure, a risk exists that the EU HDV sector may miss out on technological innovation. Countries which have introduced fuel consumption and CO<sub>2</sub> standards have observed improved levels of fuel efficiency.

According to a recent study, the introduction of fuel standards in the US, brought about a 24% fuel efficiency gain from 2011 to 2017 through the deployment of fuel-saving technologies<sup>35</sup>. It should be noted, however, that average fuel consumption of lorries started from a higher level in the US.

Recently, it has also been observed in the US that, after the introduction of the first phase of the CO<sub>2</sub> emission standards for HDVs, fuel-saving technologies such as aerodynamic kits and automated manual transmissions are being adopted at a rate much greater than expected, as larger fleets are becoming aware of the short payback periods.<sup>36</sup>

A similar conclusion can be drawn from the introduction of EU CO<sub>2</sub> standards for LDV, which lead to a sharper reduction of emissions.

**In light of the above, there is merit in analysing adding CO<sub>2</sub> emission standards for HDVs to the policy portfolio presented in Figure 5 and detailed in Annex 6. This would set out a supply side measure at EU level with the view of ensuring an effective decarbonisation of the HDVs transport sector. This is therefore the focus of the further analysis of this impact assessment.**

The analysis will concern the largest lorries belonging to the four main vehicle groups currently covered by the certification legislation. Other smaller lorries as well as buses and trailers could be addressed at a later stage, the development of the VECTO simulation tool and the certification of their emissions being a pre-requisite for any regulatory measures (for more information on the possible change of the scope of CO<sub>2</sub> emission standards for HDV see Section 5.1.1).

## 2.5 Who is affected and how

Major stakeholder groups affected include the general population, freight transport operators and logistics companies, vehicle manufactures, and automotive component suppliers. The main impacts are:

- The EU population is increasingly and negatively affected by climate change. In addition, lower air pollution will improve the wellbeing of the EU population.
- Transport operators will benefit from the lower fuel costs and the lower total cost of vehicle ownership.
- Depending on the scale of expected benefits and costs and the level of pass-through, a change in freight costs for goods could take place, affecting producers and final consumers.
- Vehicle manufacturers will be affected by the obligation to reduce CO<sub>2</sub> emissions, and will have to introduce technical CO<sub>2</sub> reduction measures. In the short-term, this is likely to result in increased production costs. There would be different impacts on

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<sup>35</sup> Transport & Environment (2018) - US Truck Fuel Efficiency Standards: Costs and Benefits Compared

<sup>36</sup> US EPA (2018). Personal communication

different manufacturers depending on the actual reduction level required and the current level of investment and focus by the manufacturer on reducing emissions.

- Component suppliers are expected to benefit from higher demand for advanced technologies. Given that EU manufacturers may need new technologies to comply with the standards, EU-based suppliers might improve their revenues.
- Sectors other than transport that emit GHGs will avoid demands to further reduce emissions to compensate for increased transport emissions. In so far as these sectors are exposed to competition, this will be important for their competitiveness.
- Energy security of the European Union will improve, as the import of oil will decrease with lower fuel consumption.

### **3 WHY SHOULD THE EU ACT?**

#### **3.1 Legal basis**

Articles 191 to 193 of the Treaty on the Functioning of the European Union (TFEU) confirm and further specify EU competencies in the area of climate change. In particular, the TFEU provides the legal basis for acting on HDV fuel consumption and CO<sub>2</sub> emissions.

The EU has already acted in the area of vehicle CO<sub>2</sub> emissions, adopting Regulations (EC) 443/2009 and (EU) 510/2011, which set limits for CO<sub>2</sub> emissions from cars and vans. These Regulations are based upon the Environment chapter of the Treaty, namely on Article 192 TFEU.

#### **3.2 Subsidiarity: Necessity of EU action**

Climate change is a transboundary problem and at the same time is a competence shared between the EU and Member States. Road freight transport also has a transboundary dimension in view of the specific service it renders – transportation of goods does not stop at the borders - and the fact that HDVs can be traded across the EU. Consequently, EU action is justified in view of both the cross-border impact of climate change and the need to safeguard a single market in road freight transport services and in HDVs.

Without action at EU level, one would have to rely on Member State initiatives to reduce HDV emissions. However, many Member States apply a preferential tax treatment for the fuel used in the HDV transport sector and there are few signals that this would change in the future. The current fuel tax levels have not triggered the necessary increase in fuel efficiency.

Furthermore, such a decision lies with Member States and it is unlikely that Member States will generally increase fuel tax levels to such a level that could trigger significant efficiency improvement as the entire fleet will be subject to the increase in fuel taxes affecting a large number of SMEs and individual transport operators. In addition, the EU taxation policy is subject to unanimity making it difficult to harmonize this policy field.

For these reasons, the possible increase in fuel tax levels could only be complementary but could not substitute the setting of CO<sub>2</sub> emission standards.

Furthermore, in case action would be left to Member States, there could be a risk of a range of national schemes to reduce HDV CO<sub>2</sub> emissions, e.g. depending on the targets set under the ESR. If this were to happen, it would result in differing ambition levels and

design parameters, which would require a range of technology options, diminishing economies of scale and fragmenting the single market.

Since manufacturers hold differing shares of the vehicle market in different Member States they would therefore be differentially impacted by various national legislations potentially causing competitive distortions. There might even be a risk that national legislation might be tailored to suit local industry.

Coordination of climate action at EU level is therefore necessary.

### **3.3 Subsidiarity: Added value of EU action**

In view of the existing single market for new HDVs, it is most cost-effective to ensure harmonised action and set CO<sub>2</sub> targets on new HDVs at EU level. It is unlikely that Member States acting individually would set targets in an equally consistent manner as shown by the widely differing tax treatment of new vehicles across the EU. Poor coordination between Member States would raise compliance costs and weaken the incentive to design fuel efficient HDVs because of the fragmentation of the European market. HDV manufacturers have recognised the risk of market fragmentation should Member States individually implement legislation to reduce HDV CO<sub>2</sub> emissions.

The automotive industry requires regulatory certainty to make the large capital investments necessary to maximise the fuel economy of new vehicles. The need for regulatory certainty was specifically highlighted by HDV manufacturers during the public consultation. Standards at EU level provide this certainty, which could not be guaranteed at Member State level.

## **4 OBJECTIVES: WHAT IS TO BE ACHIEVED?**

### **4.1 General objectives**

The general policy objective is to contribute to the achievement of the EU's commitments under the Paris Agreement (based on Article 192 TFEU).

### **4.2 Specific objectives**

The three specific objectives are the following:

1. Reduce CO<sub>2</sub> emissions from the HDV sector in line with the requirements of EU climate policy and the **Paris Agreement**.

With road transport causing one third of non-ETS emissions and emissions increasing in the last few years, reducing CO<sub>2</sub> emissions from HDVs is of key importance. This objective was considered very important by all stakeholder groups during the open public consultation.

2. Facilitate a reduction in operating costs<sup>37</sup> for **transport operators**, most of which are SMEs, and more broadly of transportation costs for consumers depending on pass-through of fuel savings.

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<sup>37</sup> Operating costs of transport operators are expected to decrease due to the positive effect of fuel savings.

This objective is related to the consumer angle of the CO<sub>2</sub> standards, aiming to create benefits for transport operators through the sales of more efficient vehicles.

3. Maintain the **technological and innovative leadership** position of EU HDV manufacturers and component suppliers.

By providing a clear regulatory signal and predictability for industry to develop and invest in fuel-efficient technologies, this initiative aims to foster innovation in a fast changing global automotive landscape.

In addition, the introduction of CO<sub>2</sub> emission standards for HDVs is expected to lead to two main co-benefits: improvements in air quality and increased energy security.

## 5 WHAT ARE THE VARIOUS OPTIONS TO ACHIEVE THE OBJECTIVES?

The options considered cover a number of elements, which are grouped into five categories: (i) CO<sub>2</sub> emission targets; (ii) Distribution of target across vehicle groups and manufacturers; (iii) Incentives for zero- and low-emission vehicles; (iv) Elements for cost-effective implementation and (v) Governance.

Annex 9.1 shows how these categories are related to the problems defined in Section 2.1.

### 5.1 EU fleet-wide CO<sub>2</sub> emission targets

#### 5.1.1 Scope

In line with the approach taken in the Certification Regulation and the VECTO simulation tool, CO<sub>2</sub> standards are to be set at the whole-vehicle level, similarly as for LDVs under the EU Regulations. In the USA, whole-vehicle CO<sub>2</sub> standards are complemented by CO<sub>2</sub> standards for engines in order to ensure that engine efficiency is improved. Engine CO<sub>2</sub> emissions are currently type approved in the EU.<sup>38</sup>

As described in Annex 8, the Certification Regulation and VECTO distinguish several HDV groups. Amongst those, group 5 vehicles (tractors with 4x2 axles and a GVW of more than 16 t) by far have the highest contribution to the CO<sub>2</sub> emissions, followed by vehicles in groups 4, 9 and 10. In view of the above, the following three options are considered with respect to the scope of the CO<sub>2</sub> emission targets:

- Scope 1: Lorries falling in groups 4, 5, 9 and 10, currently covered by VECTO (whole-vehicle CO<sub>2</sub> standards only);
- Scope 2: Lorries falling in group 5 (whole-vehicle CO<sub>2</sub> standards only);
- Scope 3: Two separate standards for whole-vehicle and engine-only CO<sub>2</sub> emissions for the vehicles falling within the scope (Scope 1 or Scope 2).

Stakeholders generally supported option 1, except for some environmental NGOs, who favoured option 3.

In the future, the development of the VECTO simulation tool will provide the necessary data that will enable other HDV types such as small lorries, buses, coaches and trailers to be made subject to CO<sub>2</sub> emission standards. As explained in Section 1.4, the planned timeline for simulating the mentioned vehicle types is 2020 – 2021.

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<sup>38</sup> CO<sub>2</sub> emissions of the vehicle engine are measured on an engine test bed and are an input parameter in VECTO. For more information on VECTO: see Section 1.4 and Annex 8.

It should be noted, though, that the availability of CO<sub>2</sub> emission data on new vehicle types should be reflected in the reporting and monitoring as well as in the certification procedures. That would require amendments to the Certification Regulation as well as the Reporting and Monitoring Regulation. Following such amendments, CO<sub>2</sub> emission standards could be extended to cover vehicle types other than those within groups 4, 5, 9 and 10.

### 5.1.2 Metric for expressing the CO<sub>2</sub> emission targets

When defining CO<sub>2</sub> emission targets, it has to be considered which phases of a vehicle's life they should cover. Several approaches are possible:

- **CO<sub>2</sub> emissions at the vehicle's tailpipe, i.e. Tank-to-Wheel (TTW) approach:**

This approach considers emissions from the combustion of fuels during the use of the vehicle. It allows taking into account the emission reduction achieved by using less carbon intensive fuels. For instance, using LNG could reduce tailpipe emissions by up to 15 to 20% compared to diesel technology. A TTW approach was supported by most of the stakeholders.

- **CO<sub>2</sub> emissions during fuel production and at the vehicle's tailpipe, i.e. Well-To-Wheel (WTW) approach:**

Next to the tailpipe emissions, the fuel used to propel a vehicle also gives rise to emissions during its production. These are the so-called Well-To-Tank (WTT) emissions. Different energy sources vary in the amount of WTT CO<sub>2</sub> emissions generated during their production. This is particularly relevant for different types of low-carbon fuels, e.g. biofuels, biogas or power-to-gas. Under a WTW approach, the targets take into account the sum of the tailpipe (TTW) and upstream (WTT) emissions. Only a few stakeholders from the fuels and gas sector supported this option during the open public consultation.

- **Full life-cycle CO<sub>2</sub> emissions:**

Under a life-cycle based approach, in addition to the WTW emissions, the target would also cover CO<sub>2</sub> emissions occurring during the manufacturing of the vehicles and their end-of-life phase. These so-called "embedded emissions" may be of greater relative importance for electric vehicles<sup>39</sup>.

A life-cycle based approach would add an enormous complexity and additional burden as it requires much more detailed reporting by lorry manufacturers. In view of the very low share of electric vehicles in the HDV sector, a metric including embedded emissions would have limited added value. Therefore, it will not be further considered in the present impact assessment. This approach was not suggested by any stakeholders.

The options considered for the metric expressing the CO<sub>2</sub> emission target are therefore:

- Metric 1: Tank-to-Wheel (TTW) approach
- Metric 2: Well-To-Wheel (WTW) approach

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<sup>39</sup> SWD (2017) 650 final of 8.11.2017, Part 2/2

### 5.1.3 Unit for expressing CO<sub>2</sub> emission targets

In terms of units to express the whole-vehicle CO<sub>2</sub> targets (options Scope 1 and Scope 2 as set out in Section 5.1.1), three options will be considered, all of which are calculated by the VECTO simulation tool:

- Metric unit 1: g CO<sub>2</sub>/km
- Metric unit 2: g CO<sub>2</sub>/tkm
- Metric unit 3: g CO<sub>2</sub>/m<sup>3</sup>km

The g CO<sub>2</sub>/km metric allows comparing the emission performance of vehicles on a unit distance basis but does not account for a lorry's payload, which may differ significantly across different vehicle groups and mission profiles. The g CO<sub>2</sub>/tkm metric also factors in payloads reflecting the characteristics of individual HDVs in terms of their freight function. The g CO<sub>2</sub>/m<sup>3</sup>km takes into account the volume the vehicle could transport taking into consideration that the general cargo type of goods is often volume sensitive.

During the public consultation, stakeholders representing manufacturers, component suppliers and the gas sector preferred expressing the targets in g CO<sub>2</sub>/tkm. By contrast, most civil society organisations preferred expressing the targets in g CO<sub>2</sub>/km.

### 5.1.4 Target levels

In order to ensure that the specific objectives are achieved, an adequate level of the overall CO<sub>2</sub> emission target needs to be defined.

However, the HDV target levels considered cannot be directly derived from the overall multi-sectoral target set under the Effort Sharing Regulation (ESR) of reducing emissions in 2030 by 30% compared to 2005. Instead, a range of options as regards the level of the HDV CO<sub>2</sub> emission targets has been determined, through a bottom-up approach, based on the cost-curves reflecting the CO<sub>2</sub> emission potentials of technological improvements. For the purpose of the assessment, the contribution of the policy to road transport emissions under those CO<sub>2</sub> target level options for new HDV has been calculated (see section 6.2.4.4.4).

The first full year for which official CO<sub>2</sub> emissions data will be available is 2019. Due to a lack of certified CO<sub>2</sub> emissions data at this stage, the CO<sub>2</sub> target level will have to be expressed in relative terms rather than as an absolute value. Thus, different options for the EU fleet-wide CO<sub>2</sub> emission targets are defined as a percentage efficiency improvement with respect to the levels of the reference year 2019.

A procedure for the adjustment of the reported 2019 CO<sub>2</sub> reference levels will also need to be introduced to address the effects of possible technical changes in VECTO, for instance with regards to payload values or the inclusion in VECTO of new technologies affecting the mission profiles.

Depending on the options as regards the timing of the CO<sub>2</sub> emission targets (see Section 5.1.5), one or two targets will need to be defined - for 2025 and/or 2030. For the option where targets are defined for both 2025 and 2030, the emission reduction trajectory between 2019 and 2030 could be either linear or non-linear (NL).



Taking all of this into account, Table 3 summarises the options considered for EU fleet-wide CO<sub>2</sub> emission target levels. The label of the options refers to the percentage reduction to be achieved in 2030<sup>40</sup>.

The baseline represents the situation where no CO<sub>2</sub> targets would be set. A certain reduction of CO<sub>2</sub> emissions would still be achieved due to autonomous technological improvements, depending on the technology cost assumptions (see Section 6.1).

The options considered cover the range of views expressed by stakeholders, with HDV manufacturers supporting a target level close to the baseline, while environmental NGOs are in favour of the most ambitious target levels considered as part of these options.

Based on the analysis of the fuel savings potentials of the currently available technologies, the full deployment into the fleet of the first two technology types shown in Table 1 in Section 2.1.2, i.e. the technologies readily available and those for which the implementation is constrained by legal restrictions soon to be lifted, would bring about 15% to 20% CO<sub>2</sub> emission savings in 2025 compared to the baseline.

**Table 3: Emission reductions expected under the baseline and options considered as regards the EU fleet-wide CO<sub>2</sub> emission target level (% reduction from 2019 level)**

	2025 <sup>41</sup>	2030 <sup>42</sup>
Baseline (base costs)	7%	12%
Baseline (high costs)	5%	10%
<b>Target Level Options</b>		
TL 20	10%	20%
TL 30NL (non-linear)	12.5%	30%
TL 30	15%	30%
TL 32	17.5%	32%
TL 35	20%	35%

### 5.1.5 Timing

Considering the likely date of adoption of the standards, the objective of contributing to achieving the 2030 climate and energy objectives, the availability of certified CO<sub>2</sub> emission data from 2019 on, as well as the lead time needed for the uptake of new technologies, the following options will be considered for defining the year(s) for which new targets could be set up to 2030.

The option of setting no binding targets, but only voluntary or aspirational ones is reflected in the baseline option for the target levels, as experience with a voluntary approach in the light-duty vehicles sector has proven that this does not result in higher emission reductions than what could be expected as a result of “autonomous improvements”.

During the public consultation, most of the HDV manufacturers as well as ACEA had identified the use of voluntary agreements with industry as one of their least preferred options to tackle CO<sub>2</sub> emissions.

<sup>40</sup> Assuming a 2030 target would be set.

<sup>41</sup> This is only relevant under options Timing 1 and 2, see Section 5.1.5

<sup>42</sup> This is only relevant under options Timing 2 and 3, see Section 5.1.5

- Target timing 1: Single CO<sub>2</sub> emission target that starts to apply in 2025. For 2030, an aspirational target would be set
- Target timing 2: A first CO<sub>2</sub> emission target starts to apply in 2025 and will continue to apply until 2029 and a second, stricter target starts to apply in 2030
- Target timing 3: Single CO<sub>2</sub> emission target that starts to apply in 2030

All options would include a review mechanism in the year 2022 when certified CO<sub>2</sub> emission data for three years will have been collected. This review would address the following:

- establish or confirm the 2030 targets for the vehicle groups covered by the first phase of the CO<sub>2</sub> emission standards;
- extend the scope to other groups of HDVs not yet covered by the first phase, taking account of the updates of VECTO and the Certification Regulation;
- review the modalities for implementation, for instance with regards to the incentive scheme for zero and low emission vehicles (see Section 5.3).

During the public consultation, a strong majority across all stakeholder groups preferred fixed dates over annual reduction targets. Stakeholders justified their preference referring to the need for planning certainty and the necessary lead time for industry to develop the technology taking account of the long product cycle for HDVs. Industry favours option 2 and environmental NGOs option 1.

Furthermore, HDV manufacturers have expressed the need to base CO<sub>2</sub> emission standards on VECTO CO<sub>2</sub> data. Such data will become only gradually available over the next years. The abovementioned review mechanism would allow certain aspects of the CO<sub>2</sub> emission standards to be reassessed and adjusted if necessary. This will address the manufacturers' concerns about the robustness of the data underpinning the CO<sub>2</sub> emission standards for 2030.

## 5.2 Distribution of EU fleet-wide CO<sub>2</sub> emission target level across HDV groups and manufacturers

The practical application of the EU fleet-wide CO<sub>2</sub> target requires consideration of the EU fleet composition and its distribution over vehicle groups and manufacturers, who in the end will have to demonstrate compliance. Technical differences between HDVs covered by the various vehicle groups (see Annex 8, Section 8.2) mean that these groups have intrinsically different CO<sub>2</sub> emission performances.

These differences should be considered when distributing the EU fleet-wide emission targets across the HDV groups. Depending on the predominant use of the vehicles for one of the two mission profiles, each of the four vehicle groups considered could be further split into two sub-groups, either Long Haul or Regional Delivery. Information on the weighting of mission profiles for calculating the regulatory CO<sub>2</sub> emissions is given in Annexes 11 and 12.

In order to implement the legislation, it needs to be clearly established which target(s) each manufacturer would have to comply with. Two different options will be considered:

- **Distribution 1 - Separate targets per HDV sub-group:** The CO<sub>2</sub> emission reduction targets (in percentages) for each HDV sub-group are determined such that the total costs across all HDVs covered, i.e. the overall technology costs minus the

fuel savings, are minimized. Each of the sub-group targets would apply for each of the manufacturers.

This would allow for reflecting the differences in cost-effective emission reduction potentials between vehicle sub-groups. For this reason, there would be no need for additional flexibility for individual manufacturers in implementing these targets.

- **Distribution 2 - Single target per manufacturer:** The same CO<sub>2</sub> emission reduction target (in percentages) applies for all HDV sub-groups covered. The specific manufacturer targets are defined as the average of those sub-group targets, weighted according to the number of lorries registered within each sub-group and a factor reflecting their utility. The utility factor would depend on the unit for expressing the target and, where relevant, would cover mileage (km), payload (t), volume (m<sup>3</sup>).

This option is described in further detail in Annex 11.

It should be noted that both options will lead to different target levels in absolute terms for the different HDV sub-groups due to the significant differences in fuel consumption per 100 tkm as illustrated in Annex 11.

During the stakeholder consultation, manufacturers expressed their support for option 2.

### 5.3 Incentives for Zero- and Low-Emission Vehicles (ZEV/LEV)

The July 2016 Commission's European Strategy for Low-Emission mobility<sup>43</sup> highlighted the increasing role of zero- and low-emission vehicles in delivering CO<sub>2</sub> reductions in the road transport sector, especially in the medium- and long-term. In view of the low uptake of these vehicles in the HDV sector, several options are considered with the aim of incentivising their deployment.

#### 5.3.1 Scope of the ZEV/LEV incentive

In order to identify which vehicles would qualify for the ZEV/LEV incentive, it is necessary to define which types of HDV would be eligible. Two options are considered in this respect:

- **Scope 1: ZEV only**, meaning that only HDVs with CO<sub>2</sub> emissions of zero would qualify;
- **Scope 2: ZEV and LEV**, meaning that all HDVs with CO<sub>2</sub> emissions significantly below the fleet-wide average would qualify.

Under option Scope 2, LEV would be vehicles emitting less than half of the average fleet-wide emissions. This approach is in line with the one taken for LDV. As fleet-wide average HDV emissions are currently around 800 g CO<sub>2</sub>/km and taking into account the expected efficiency improvements by 2025, a HDV would qualify as a LEV if it emits less than 350 g CO<sub>2</sub>/km. This would correspond, using the current weighing of VECTO mission profiles, to 30 g CO<sub>2</sub>/tkm.

Furthermore, as proposed for cars and vans from 2025 on<sup>44</sup>, LEV with the lowest emissions would be incentivised more by taking into account for the purpose of the

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<sup>43</sup> COM(2016) 501 final

<sup>44</sup> COM(2017) 676 final

crediting system the emission level of the vehicle. Each ZEV and LEV would be counted as  $1 - (E/350)$ , with E being the vehicle's CO<sub>2</sub> emissions in g/km.

The use of other types of alternative fuels than electricity or hydrogen, such as biodiesel, biogas or e-fuels, has been considered as part of the option on a Well-To-Wheel (WTW) approach for the metric (see Section 5.1.2). Tailpipe CO<sub>2</sub> emissions of vehicles running on such fuels are comparable with those of vehicles running on conventional fossil fuels. In these cases, the potential emissions savings of using the alternative fuels would only occur at the stage of the production of the fuels.

### 5.3.2 Type and level of incentive

Regulatory tools used or considered for incentivising the uptake of ZEV/LEV are those which were considered in the context of light-duty vehicles<sup>45</sup>:

- **ZEV/LEV incentive type 1:** super-credit system

Under the current Cars and Vans Regulations, a "super-credit" modality exists, under which, during a limited number of years around the entry into effect of new CO<sub>2</sub> target values, ZEV and LEV may be counted as more than one vehicle for the purpose of calculating the average specific emissions of a manufacturer<sup>46</sup>.

In analogy, under option 1, each ZEV/LEV registered by a manufacturer in a given year would be counted multiple times<sup>47</sup> for the purpose of calculating the average specific emissions of the manufacturer. In order to avoid too much weakening of the CO<sub>2</sub> target, a cap needs to be established on the number of super-credits that may be used. Drawing on the rules established for cars<sup>48</sup>, this cap could be set so that average specific emissions of the manufacturer are not lowered by more than 2.5% to 3%.

- **ZEV/LEV incentive type 2:** one-way crediting system based on a benchmark for the ZEV/LEV share of the fleet
- **ZEV/LEV incentive type 3:** two-way crediting system based on a benchmark for the ZEV/LEV share of the fleet

Under Option 2 and 3, a crediting system is used, which works in connection with a manufacturer's specific CO<sub>2</sub> target. A benchmark is defined for the share of ZEV/LEV in the new fleet in a given year. The specific CO<sub>2</sub> target of a manufacturer exceeding this ZEV/LEV benchmark will be relaxed depending on the extent to which the benchmark is exceeded (1% less strict target for each additional percent of ZEV/LEV), subject to a cap. In addition, under option 3), the specific emissions target of a manufacturer would be tightened in case he would register less ZEV/LEV than the benchmark level.

In order to avoid too much weakening of the CO<sub>2</sub> target, a cap would be set allowing a manufacturer's specific CO<sub>2</sub> target not to be relaxed by more than 2.5%.

- **ZEV/LEV incentive type 4:** ZEV/LEV binding mandate:

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<sup>45</sup> SWD(2017) 650 final

<sup>46</sup> The maximum multiplier for cars and vans in the context of the 2015, resp. 2017 CO<sub>2</sub> emission targets was 3.5. The maximum multiplier for cars in the context of the 2021 targets is 2.

<sup>47</sup> In order to take into account the emissions of the ZEV/LEV, the maximum multiplier would apply for ZEV and a variable multiplier would apply for LEV, according to a linear scale as a function of the emissions.

<sup>48</sup> In the current Cars Regulation, the cap for super-credits is set at 7.5 g CO<sub>2</sub>/km, as a total over 3 years, i.e. on average at around 2.5 g CO<sub>2</sub>/km annually and this against a target in 2021 of 95 g CO<sub>2</sub>/km.

Under this option, each manufacturer's fleet of new HDV would need to have at least the share of ZEV/LEV established by the binding mandate.

- **ZEV/LEV incentive - variant:** allow ZEV HDV, which are outside the scope of the Regulation, to be counted for the purpose of the ZEV/LEV incentive.

Under this variant, which could work under each of the four options considered, next to the HDV falling with the scope of the Regulation, also other HDV, which are ZEV and which are registered by the same manufacturer, would be taken into account for the purpose of the incentive mechanism.

This would mean for example that a manufacturer registering zero-emission buses or small lorries could obtain super-credits for those vehicles or that those vehicles could count towards meeting the benchmark or mandate level established.

This approach would currently only work for ZEV, as they could be defined as having zero emissions according to the type-approval properties of their engines, i.e. independently of the certification of the whole vehicles based on VECTO.

The situation is different for LEV, the CO<sub>2</sub> emissions of which can only be determined once they are covered by the Certification Regulation. Considering those LEV for the purpose of these incentives would also require further analysis on the appropriate level of the threshold for defining such vehicles.

Based on the on-going further development of VECTO (see Annex 8.1), it is expected that by 1 January 2025 also these vehicles will be subject to the Certification Regulation.

Finally, as zero-emission buses are to some extent already incentivised via requirements on public tendering through the proposed revision of the Clean Vehicle Directive, and to avoid that the incentive would exclusively target one vehicle group, a restriction would apply next to the above-mentioned caps. This would limit the share of credits that could be attributed to buses and smaller lorries to a maximum of 50% of the cap (under options 1-3) or mandate (under option 4).

During the public consultation, HDV manufacturers expressed their support for the introduction of super-credits (option 1). Environmental NGOs were in favour of introducing a mandate (option 4).

#### **5.4 Elements for Cost-Effective Implementation (Flexibilities)**

Elements increasing the flexibility for manufacturers for implementing the CO<sub>2</sub> standards set, while not undermining the overall objectives of the policy should lower the costs of compliance and improve the cost-effectiveness of the policy. Such options have been used in the LDV CO<sub>2</sub> Regulations. The evaluation of those Regulations judged these flexibilities positively in terms of their impacts. Flexibilities have also been used in the US under the HDV emissions legislation.

The majority of stakeholders across all stakeholder groups was in favour of pooling, banking/borrowing, and trading to support the cost-effective implementation of the targets. However, civil society organisations supported trading only and argued that the other options may undermine the legislation. HDV manufacturers supported only the introduction of exemptions and of banking and borrowing.

HDV manufacturers also suggested to introduce an eco-innovation scheme as in the LDV legislation, where it covers innovative CO<sub>2</sub> reducing technologies, the effect of which cannot be demonstrated during the physical type approval test cycle.

However, for HDVs, CO<sub>2</sub> emissions are not measured on a physical test cycle but simulated with VECTO. The possibilities of considering new technologies in VECTO are therefore much wider and VECTO will be further improved and updated to cover the effects of new innovative technologies, as illustrated in Annex 8. This is a more straightforward and transparent procedure than introducing a new parallel eco-innovation scheme. As a result, this option is not considered further for the analysis.

#### 5.4.1 Exemptions

While most of the HDVs in the groups 4, 5, 9, 10 are used for delivery purposes, there are also a series of HDV, which are used for other purposes, such as construction lorries, garbage lorries, concrete mixers etc. Together, these vehicles can be described as "vocational vehicles". According to data from HDV manufacturers, these vocational vehicles represent less than 2% of the fleet of each manufacturer.

In view of their particular uses, vocational vehicles differ substantially from the HDVs used for the delivery of goods. Due to their technical characteristics and relatively small annual mileage, the possibilities of reducing CO<sub>2</sub> emissions are both more limited and less cost-efficient than for delivery vehicles.

During the public consultation, HDV manufacturers called for exempting vocational vehicles from the requirements of CO<sub>2</sub> emission standards.

Currently, vocational vehicles cannot be identified on the basis of clear technical criteria. However, the necessary changes will be made in the type approval legislation to ensure that this identification is possible. This requires the introduction of a multi-stage type approval in the HDV CO<sub>2</sub> certification process.

Before these changes are made in the type approval legislation, vocational vehicles are identified on the basis that they are not certified on a delivery-type mission profile in VECTO.

Consideration was also given to small-volume manufacturers, but the analysis has shown that there are currently no such manufacturers operating in the EU market and there is no indication of new entrants beside manufacturers of zero-emission vehicles, which would not have difficulties in meeting the targets. As a result, the option of exempting small-volume manufacturers was not considered further. No stakeholders have asked for such exemptions.

Consequently, the only option considered regarding exemptions is:

- Exempt vocational vehicles of a manufacturer's fleet

#### 5.4.2 Flexibilities across manufacturers

In order to provide manufacturers with additional flexibility for the purpose of achieving compliance with the target, the following options are considered:

- Target flexibility 1: Allow pooling between manufacturers

A group of individual manufacturers may agree to form a "pool", which enables them to be considered as a single entity for the purpose of compliance with the joint target.

- Target flexibility 2: Allow trading between manufacturers

Trading would allow individual manufacturers (or pools) to trade credits depending on their performance. A manufacturer (pool) overachieving its specific CO<sub>2</sub> emissions target

would obtain credits that could be sold to another manufacturer (pool), which would otherwise not meet its target.

The main distinction with pooling is that trading does not require an upfront decision by manufacturers on which other manufacturer(s) to associate with. The decision to trade would take place at the time the provisional emission performance of the manufacturer (pool) is known.

#### 5.4.3 Flexibilities across different target years

Compliance checks are necessary to ensure effective implementation of the CO<sub>2</sub> emission targets. As indicated in Section 5.1.5, target compliance would be assessed based on the emissions in a given year. In this respect, additional flexibility could be provided and the following options are considered.

- **Target compliance 1:** annual compliance assessment

Under this option, target compliance would be assessed on the basis of the specific emissions in one calendar year. In case of non-compliance, penalties would apply (see Section 5.5.3). This option was supported by environmental NGOs.

- **Target compliance 2:** banking and borrowing

Under this option, manufacturers could use banking and/or borrowing of CO<sub>2</sub> credits to achieve the CO<sub>2</sub> targets applying in a given year. The rationale behind it is that the desired outcome in terms of an overall CO<sub>2</sub> emission target should be achieved by a certain time, while the optimal route to that point may differ between actors. This is in particular relevant for the HDV sector where design cycles are much longer than for cars, around 10 to 15 years. Under this option, early action by manufacturers could also be rewarded.

*Banking* would mean that if in a given year the CO<sub>2</sub> emissions of a manufacturer are below the target, the manufacturer could carry over the difference as CO<sub>2</sub> credits for future compliance purposes. In case its CO<sub>2</sub> emissions would exceed the target in one of the following years, the manufacturer could offset these excess emissions with the ‘banked’ CO<sub>2</sub> credits.

*Borrowing* would mean that, in a given year, a manufacturer could comply with its CO<sub>2</sub> target by ‘borrowing’ CO<sub>2</sub> credits, which would have to be ‘paid back’ by using credits obtained in subsequent years from overachieving the target.

The design elements of this option are particularly sensitive considering the specificities of the HDV market and the uncertainties on the future levels of emissions.

A more detailed description of the option is provided in Annex 9.4.

HDV manufacturers have expressed support for the banking and borrowing option.

## 5.5 Governance

The effectiveness of the CO<sub>2</sub> targets in reducing real emissions depends on the one hand on the representativeness of the VECTO simulation results with respect to average real-world driving, and on the other hand on the extent to which the HDVs placed on the market conform to the reference vehicles tested at type approval.

### 5.5.1 Real-world emissions

The effectiveness of technologies to reduce real-world CO<sub>2</sub> emissions of vehicles is affected by the actual driving conditions, which vary significantly. Therefore, emissions determined through VECTO simulation will always differ from the emissions achieved in the real world<sup>49</sup>. As such, this is not problematic as long as the expected divergence between the VECTO values and the real world emissions will remain at the same level over time.

It is current practice that most HDV manufacturers equip their vehicles with non-standardised fuel metering devices on a voluntary basis. The information derived from these devices could be reported and used for establishing the magnitude of deviations between VECTO CO<sub>2</sub>/fuel consumption values and real-world values. Consideration could be given to making such reporting mandatory in the future.

In addition, it could be considered to mandate the use of standardised devices for measuring fuel consumption, ideally together with load sensors, and to have the resulting data reported anonymously.

The following options are therefore considered:

- **Real-world emissions 1:** Collection, publication and monitoring of real world fuel consumption data reported by manufacturers using currently available devices.
- **Real-world emissions 2:** Collection, publication and monitoring of real-world fuel consumption data reported by manufacturers, based on mandatory standardised devices.

Under option 1, the Commission would be empowered to determine the conditions for collecting and publishing the data, taking into account relevant data protection requirements. Under option 2, the Commission would in addition be empowered to mandate in type approval legislation the installation of standardised devices in all new vehicles.

A clear majority of stakeholder groups considered it important to develop processes for assessing the certified CO<sub>2</sub> emissions against real driving emissions. Only some component suppliers and vehicle manufacturers were either neutral or explicitly against.

### 5.5.2 Market surveillance

Under type-approval legislation, a procedure is currently being developed to verify the type-approved CO<sub>2</sub> emissions at the stage of production. A procedure for verifying the CO<sub>2</sub> emissions of vehicles on the road, i.e. a so-called in-service conformity test does not yet exist for HDVs. The following option is therefore being considered:

- **Market surveillance 1:** Introduce in-service conformity tests, the obligation to report deviations and the introduction of a correction mechanism.

Under this option, a mechanism would be put in place to detect deviations from the type approval values as part of the conformity of production tests. This would have to be

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<sup>49</sup> CARB 2015, Staff Report: Technical Status and Proposed Revisions to On-Board Diagnostic System Requirements and Associated Enforcement Provisions for Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) (<https://www.arb.ca.gov/regact/2015/obdii2015/obdii2015isor.pdf>)



developed under the type approval framework, for instance during verification tests of vehicles in-service.

Furthermore, an obligation would be introduced in the CO<sub>2</sub> emissions legislation for Member States and manufacturers to systematically inform the Commission of any findings resulting from conformity of production tests or, where applicable, from in-service conformity tests, and of deviations from the type approved CO<sub>2</sub> emissions.

The CO<sub>2</sub> monitoring data for a manufacturer would be corrected in case of serious deviations from the type approval values, which cannot be technically or otherwise justified. The Commission would be empowered to define the details of the procedures.

During the open public consultation, most automotive component suppliers and vehicle manufacturers were against or to a lesser extent neutral on the introduction of an ex-post mechanism requiring compliance of the certified CO<sub>2</sub> emissions with real-driving emissions. Such an ex-post feedback mechanism was supported by logistics operators, vehicle fleet operators, and civil society organisations.

### 5.5.3 Penalties for non-compliance

Ensuring compliance is a key element that guarantees the effectiveness of any regulatory requirement. Financial penalties associated with the failure to meet the required emission standards may act as an incentive for manufacturers to meet their emission targets.

In order to be effective, financial penalties should be set at a level significantly exceeding the average marginal cost of the technologies needed to meet the targets. Under the current LDV legislation<sup>50</sup> the excess emissions premium for exceeding CO<sub>2</sub> emission targets from 2019 on is €95 per g CO<sub>2</sub>/km for each new vehicle registered in the year of exceedance. As HDVs have an average lifetime mileage of around 1.2 million km, which is about six times higher than LDVs, this penalty level would translate into a €570 per g CO<sub>2</sub>/km penalty for HDVs. Using an average payload value of about 12 tons as set out in VECTO, this value translates into €47.50 per gCO<sub>2</sub>/tkm, which has been rounded to €50/tkm.

The following option is considered with respect to the introduction of financial penalties for manufacturers not complying with their specific CO<sub>2</sub> emission targets:

- **Penalties 1:** Financial penalties.

The penalty would apply to each newly registered vehicle of a manufacturer in the year of exceedance. The level of the penalty will be assessed considering the marginal technology costs and the metric chosen to express the target level set.

Implementation of these penalties at manufacturer level would need to take account of how the specific targets have been derived from the EU fleet-wide target and the vehicle sub-group targets (see Section 5.2).

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<sup>50</sup> Regulation 443/2009 of the European Parliament and of the Council

## 6 WHAT ARE THE IMPACTS OF THE POLICY OPTIONS?

### 6.1 Methodology

The quantification of the impacts, in particular as regards the target levels and their distribution across vehicle groups relies on a suite of models and a dedicated set of cost curves covering a broad range of up-to-date technologies for reducing CO<sub>2</sub> emissions from HDVs.

These cost curves, which show the CO<sub>2</sub> reduction potential and costs for over 50 technologies, were determined as part of a study carried out by Commission contractors<sup>51</sup> and work by the JRC<sup>52</sup>. The technologies considered include those that are currently already utilised in vehicles in the marketplace, as well as those expected to be available in the 2020-2030 period.

In the preparation of the cost curves, the (im)possibility to combine technologies has been duly taken into account, as has their pre-existing market penetration in the vehicle fleet and possible overlaps in the CO<sub>2</sub> saving potential of technologies when combined.

Stakeholders were given the opportunity to comment on the work of the study throughout its progress. Two types of cost curves have been considered:

- i. Base cost assumption: derived from the above mentioned study;
- ii. High cost assumption: reflecting manufacturers' views

The high cost assumption has been added in the assessment in order to reflect the views expressed by HDV manufacturers during bilateral meetings highlighting uncertainties surrounding the effectiveness and costs, in particular R&D, of the more advanced technologies many of which are only at the prototype stage, in particular in a 2025 perspective<sup>53</sup>.

As regards the technologies readily available, the uncertainty regarding the data used for the cost curves is small. As described in Section 2.1.2, the full deployment of those technologies would bring about 15% to 20% CO<sub>2</sub> emission savings in 2025 compared to the baseline.

The models used and the link between the new baseline and policy scenarios with the "Reference Scenario 2016"<sup>54</sup> are extensively described in Annex 4.

The PRIMES-TREMOVE model was used to project the evolution of the road transport sector. It was consistently used for climate, energy and transport initiatives in the past years. In addition, the DIONE model developed by the JRC was used for the cost assessment. The macro-economic model EXIOMOD developed by TNO was used to quantify the impacts on GDP and sectoral turnover. It takes input from PRIMES-TREMOVE, including fuel consumption from lorries, and annuity payments for capital costs for road transport vehicles, to quantify the impact on other sectors of the economy.

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<sup>51</sup> "Heavy Duty Vehicles - support for preparation of impact assessment for CO<sub>2</sub>", study for the Commission by TNO and consortium, report to be published;

<sup>52</sup> "Heavy Duty Vehicles CO<sub>2</sub> Emission Reduction Cost Curves and Cost Assessment – enhancement of the DIONE model", JRC, to be published

<sup>53</sup> See Table 1 in Section 1.2.

<sup>54</sup> <https://ec.europa.eu/energy/en/data-analysis/energy-modelling>

## 6.2 EU fleet-wide CO<sub>2</sub> emission targets

### 6.2.1 Scope

#### 6.2.1.1 Options Scope 1 and Scope 2

Options Scope 1 (covering HDV groups 4, 5, 9 and 10) and Scope 2 (covering only group 5) are assessed together as they both rely on whole-vehicle CO<sub>2</sub> standards and differ only in scale. As the magnitude of the economic, social and environmental impacts of these options will mainly depend on the CO<sub>2</sub> target level, the quantitative assessment is addressed in Section 6.2.4.2.

#### *Economic Impact*

The economic impacts of options Scope 1 and 2 relate to the scale of the investments needed to introduce the CO<sub>2</sub> abatement technologies and the impact of the resulting fuel savings on the economy as a whole.

Most emission reduction technologies can be applied in all lorry groups. Technology costs are mainly composed of two parts: (1) variable costs and (2) fixed costs, the share of which depends on economies of scale.

Even though small differences may exist for some technologies, the cost analysis indicates that variable technology costs are largely similar across the four lorry groups relevant for the options considered here. This is elaborated further in Section 6.3.

As the relative share of the fixed technology costs for an individual vehicle decreases with the number of vehicles for which the technology is installed, economies of scale make option Scope 1 more cost-efficient for achieving a given CO<sub>2</sub> emission reduction target. This also entails that this option might be more beneficial in terms of innovation development and strengthening of manufacturers' technological leadership.

Furthermore, as a larger number of their vehicles would be covered under Scope option 1, this option would translate into higher overall fuel savings for transport operators.

#### *Social Impact*

There is no particular social impact of the options Scope 1 and Scope 2.

#### *Environmental Impact*

As the vehicle groups 4, 5, 9 and 10 together account for some 65% to 70% of total HDV CO<sub>2</sub> emissions, option Scope 1 is expected to have a firmly positive and sizeable environmental impact as it addresses all the major CO<sub>2</sub> emitters in the HDV sector.

Under option Scope 2, the legislation would cover some 50% of total HDV emissions. With the target levels and all other design elements being equal, this option will have a positive environmental effect in reducing emissions, but on a smaller scale as it focuses on one single lorry group.

#### 6.2.1.2 Option Scope 3

Under option Scope 3, two separate standards for whole-vehicle CO<sub>2</sub> and the engine-only CO<sub>2</sub> emissions would be set.

#### *Economic Impact*

Option Scope 3 would not allow manufacturers to achieve the required level of emissions in the most cost-efficient way by combining all available CO<sub>2</sub> reduction technologies. It

would most likely result in higher compliance costs. It would also deviate from a technology neutral approach, limit technological flexibility and undermine innovation in non-engine related CO<sub>2</sub> reduction technologies.

#### *Administrative burden*

This option would create an additional administrative burden due to the additional reporting and compliance systems that would need to be put in place to regulate separately the performance of engines.

#### *Social Impact*

There is no particular social impact of this option.

#### *Environmental Impact*

By setting whole-vehicle standards, engine emissions would already be regulated as they are captured by VECTO. Introducing engine-only standards on top of whole-vehicle standards would therefore not necessarily create a higher environmental ambition level.

There could be a positive environmental impact if the requirements of the engine-only standards would go beyond the requirements of the whole vehicle standards. However, at least the same level of environmental impact can be achieved if the whole-vehicle standards are set with a more ambitious target level.

During the open public consultation, some civil society organisations gave preference to this option as they consider it would allow better exploiting the emission reduction potential of the engines. However, this especially concerned smaller vehicles that are not yet covered by VECTO.

### *6.2.2 Metric for expressing the CO<sub>2</sub> emission targets*

#### *6.2.2.1 Metric 1: Tank to Wheel (TTW) approach*

#### *Economic Impact*

The economic impact will depend on the target level chosen.

#### *Environmental Impact*

Under this option, the legislation focuses on the vehicle's CO<sub>2</sub> efficiency. The TTW approach is currently used for CO<sub>2</sub> targets for LDV, where it effectively contributed to reduce CO<sub>2</sub> emissions from cars and vans. The actual environmental impact will depend on the target level chosen. In case a higher uptake of more fuel-efficient vehicles reduces the overall demand for fuels, this would also lower WTT emissions.

The focus on vehicle efficiency also ensures that investments in research and development in this area would be incentivised with a corresponding positive effect on technological leadership.

#### *Other considerations*

This option would be directly linked with the VECTO and Certification Regulation, which provide tailpipe CO<sub>2</sub> emission values. The evaluation study of the Cars and Vans Regulations noted that the TTW approach has proven to be an effective way of triggering the uptake of vehicle technology and starting a shift towards alternative powertrains.

The TTW approach allows vehicle manufacturers and automotive component suppliers to focus their investments towards technologies increasing vehicles' fuel efficiency which is

within their remit of decision making. Fostering the uptake of those technologies lowers investment costs and technology costs thanks to economies of scale. During the public consultation, most stakeholders supported this approach.

#### 6.2.2.2 Metric 2: Well to Wheel (WTW) approach

##### *General considerations*

As explained in the impact assessment<sup>55</sup> accompanying the Commission's proposal setting CO<sub>2</sub> emission performance standards for passenger cars and vans for the period after 2020, the two arguments most frequently used in favour of a WTW metric are that this would allow:

- i. accounting for the WTT emissions of electricity generation, particularly as the power sector is not yet fully decarbonised;
- ii. rewarding the use of low-carbon fuels like bio-ethanol, bio-methane or synthetic fuels produced from renewable electricity.

As regards the second point, particularly the Commission's 2016 RED-II proposal provides for the strongest possible economic incentives by setting sales mandates for the deployment of such low-carbon fuels across all sectors, including freight transport. This means that a WTW metric would *de facto* constitute double regulation for these sectors.

##### *Environmental impacts*

There is a risk that a WTW approach could undermine the environmental effectiveness of EU legislation as emission reductions counted under RED-II would be double counted under the vehicles legislation. This would make it difficult for Member States to estimate the emission reductions in the transport sector stemming from RED-II and the improvements in HDV CO<sub>2</sub> efficiency improvements, particularly as the consumption of biofuels is not evenly distributed among Member States.

In order to maintain the overall environmental ambition of the two legislative acts together, a WTW approach would most likely require more stringent target levels in either the renewable energy or the vehicle emissions legislation.

##### *Other considerations*

In view of the very limited uptake of electrified HDV, the need to account for the WTT emissions from electricity is less relevant for HDVs.

In addition, as the WTW emissions are not a property of the vehicle alone, it would be very difficult to establish a target value which is accurate, fair and cost-effective. Uncertain ex-ante assumptions would have to be used to account for the potential use of low-carbon fuels as it is not possible to determine upfront on which fuel a vehicle with a conventional powertrain will run. An ex-post crediting approach based on the actual fuel use and GHG emission factors could serve as an alternative, but would face similar problems as it would be very difficult to set WTT factors for the different fuels available on the market.

Besides these major uncertainties, vehicle manufacturers have no influence on the fuels used by the vehicle operator and they may therefore be held responsible for emissions

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<sup>55</sup> SWD (2017) 650 final

they have no or little control of. This approach was supported by the fuel industry and transport operators.

### 6.2.3 Unit Metric

Payloads, mileage and transport volume are fixed parameters for each mission profile as part of the VECTO simulations. This means that, for a given mission profile, the numerical values of the VECTO simulation corresponding to different unit metrics are proportional. As a result, the choice of the unit metric is mainly a question of presentation.

The unit g CO<sub>2</sub>/km is currently used for setting CO<sub>2</sub> emission limits for cars and vans. Using this unit for HDVs would ease the comparison with the light duty sector. It is also most commonly used in existing publications within the sector. However, this metric would not represent the fact that lorries carry heavy or voluminous loads.

The use of this metric is supported by environmental NGOs but not by the transport sector, which calls for the targets to reflect the transport utility.

The unit g CO<sub>2</sub>/tkm expresses CO<sub>2</sub> emissions in relation to the mileage travelled and the mass of goods transported. It is supported by manufacturers and transport operators.

The unit g CO<sub>2</sub>/m<sup>3</sup>km expresses CO<sub>2</sub> emissions in relation to the mileage travelled and the volume of goods the vehicle could potentially transport. From a technical perspective, CO<sub>2</sub> emissions and transport volume are only weakly correlated. Furthermore, the current certification regulation does not distinguish between the possible different transport volumes as it assumes standard bodies and trailers added to the base vehicles. This unit metric is therefore not appropriate for the existing setup of the certification process.

The choice of unit metric will not have an effect on innovation.

### 6.2.4 Target levels

#### 6.2.4.1 Fleet composition

Different CO<sub>2</sub> target levels will not only affect the uptake of fuel-efficient technologies within a given vehicle category (powertrain), but may also change the share of different powertrains in the EU fleet. The results obtained from the PRIMES TREMOVE model show a gradual increase in the uptake of LNG lorries at the expense of diesel fuelled lorries as CO<sub>2</sub> targets get tighter. Under the baseline, with the base cost assumptions, the share of diesel HDV is projected to be 97.6% in 2025 and 96.3% in 2030, the remainder of the fleet being LNG lorries. The diesel share becomes 94% in 2025 and 89.6% in 2030 under the option TL20 and reduces further to 87.2% in 2025 and 77.5% in 2030 under the option TL35. More specific information is available in Annex 10.1.

#### 6.2.4.2 Economic impacts

In this section, the following economic impacts will be considered:

- (i) Net economic savings from different perspectives (societal, first use, second use)
- (ii) Energy system impacts and transport activity impacts
- (iii) Macro-economic impacts in terms of changes in GDP and sectoral aspects

*Net economic savings taking different perspectives*

The direct economic impacts of the options have been assessed by considering the changes compared to the corresponding baseline in technology costs and fuel costs for an "average" new lorry, registered in 2025 or in 2030.

An "average" new lorry of a given year is defined by averaging the contributions of the different vehicle groups, weighted according to their market penetration as estimated. The new fleet composition in a given year results from the need to comply with the requirements of the new policy. Therefore, the different policy options lead to different projected fleet compositions, characterised by different shares of powertrain types (diesel, LNG, etc.) in the different vehicle groups.

As the vehicle groups reflect certain technical characteristics depending on the use of the vehicle, vehicles in the different groups cannot substitute each other. Therefore, in the model, the shares of vehicles in the different groups were kept constant on the basis of the sales data received from manufacturers for the 2016 fleet.

For this analysis, the following three indicators have been used:

- i. **Net economic benefits over the vehicle lifetime from a societal perspective:**  
This parameter reflects the change in net costs over the lifetime of 15 years of an "average" new lorry without considering taxes and using a discount rate of 4%. It also includes the CO<sub>2</sub> avoided costs.
- ii. **Total cost of ownership (TCO) for the first use (TCO-first use):**  
This parameter reflects the change in net costs, during the first five years after registration of use, i.e. the average time the first buyer is using the vehicle. Taxes are included, except VAT in view of the commercial use of the vehicles, and a discount rate of 9.5% is used.
- iii. **Total cost of ownership (TCO) for the second use (TCO-second use):**  
This parameter reflects the change in costs, from the sixth year of the lorry onwards. Again, taxes are included and a discount rate of 9.5% is used.<sup>56</sup>

#### *Cost assumptions*

As explained in Section 6.1, two types of cost curves have been used for the analysis to reflect base and high costs assumptions. For the calculation of the net costs and savings under the two cost assumptions, the corresponding baseline was used. A sensitivity analysis on the economic impacts with varying international oil price is presented in Annex 10.6.

##### *6.2.4.2.1 Net economic benefits over the vehicle lifetime from a societal perspective*

Figure 8 shows the net economic benefits per vehicle over the vehicle lifetime from a societal perspective expressed as the difference from the baseline for an average lorry registered in 2025 and in 2030 under the different target level options. These economic benefits are the sum of the net savings and the avoided CO<sub>2</sub> costs. As shown in Annex 10.2, the net savings are the difference between the fuel savings and the incremental capital costs, which in this case are equal to the additional manufacturing costs.

Both in 2025 and in 2030, very significant net benefits can be realised under all options with both base and high cost assumptions. Net benefits are profoundly higher compared

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<sup>56</sup> The transfer of the vehicle from the first to the second owner is modelled by assuming a residual value of 44% of the vehicle, which is applied to the base vehicle and fuel saving technologies alike.

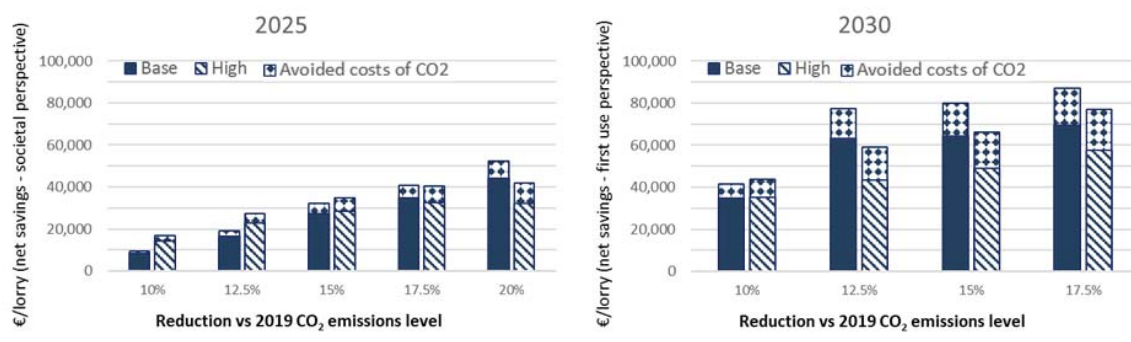
to cars and vans<sup>57</sup>. Lorries have a much higher fuel consumption per kilometre and run much higher mileages compared to cars and vans.

With the base and the high cost assumptions, net benefits are highest under the most ambitious option TL35 in both 2025 and 2030.

Whether net savings under the various options are higher or lower under the base or high costs assumptions depends on a number of factors. These include the difference in autonomous improvements under the two baselines and the increase in LNG share in the fleet needed to meet the higher levels of ambition.

The avoided cost of CO<sub>2</sub> increase as the CO<sub>2</sub> target gets stricter. See more detailed information in Annex 10.3.

**Figure 8: Net economic benefits, including avoided CO<sub>2</sub> costs, over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/lorry)**



#### 6.2.4.2.2 TCO-first use (5 years)

Figure 9 shows the net savings, expressed as the difference from the corresponding baseline, from a first-use perspective over five years for an average new lorry registered in 2025 and in 2030 under the different target level options considered. The underlying capital costs and fuel savings are shown in Annex 10.4.

Both in 2025 and in 2030, considerable cumulative net savings occur over five years for all options considered, both for the base and high cost assumptions. Net savings are slightly lower for the high cost case. However, benefits are significantly smaller compared to the societal perspective. The difference mainly represents the external CO<sub>2</sub> costs avoided.

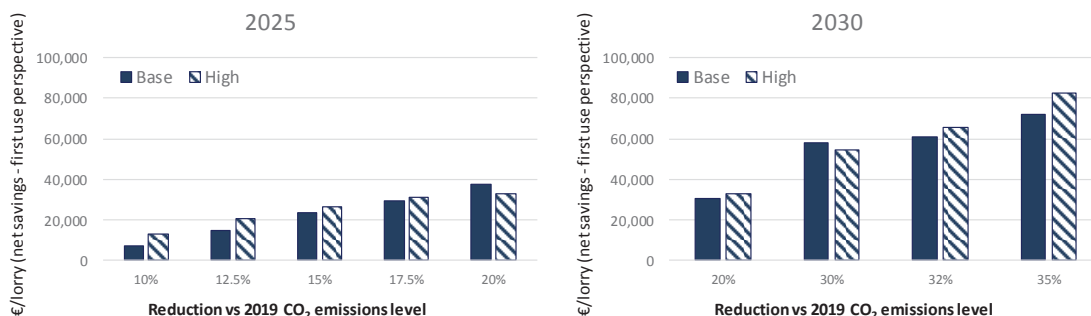
From the perspective of the truck operator, the cumulative net savings represent between 0.01 and 0.05 EUR per km in 2025 or 1% to 4% of the total operating costs depending the options considered. In 2030, the ranges are 0.04 to 0.11 EUR per km or 3% – 12% of the total operating costs.

Under both cost assumptions, net savings are highest with option TL35 in 2025 and in 2030.

<sup>57</sup> SWD (2017)650 final



**Figure 9: Net economic savings from a first use (5 years) perspective in 2025 and 2030 (EUR/lorry)**



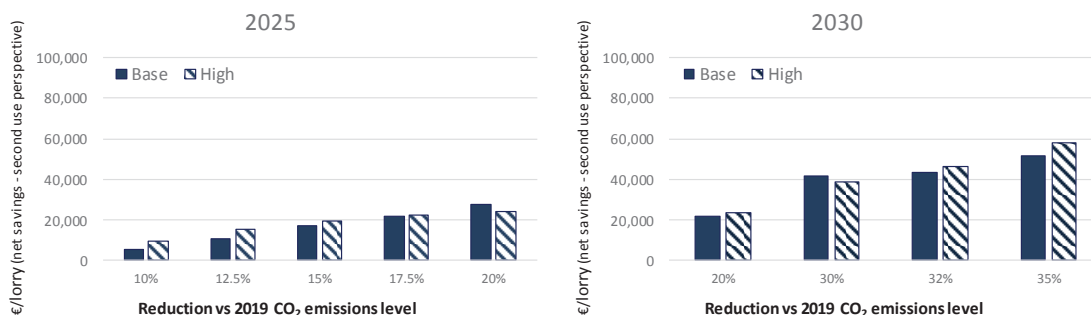
#### 6.2.4.2.3 TCO-second use

Figure 10 shows the net savings from a second use perspective under the different target level options, expressed as the difference with the baseline under the two cost assumptions, for an average new lorry registered in 2025 and in 2030. The underlying capital costs and fuel savings are shown in Annex 10.5.

Both in 2025 and in 2030, considerable net savings occur, which are roughly one third smaller during the second use compared to the first use. Under both cost assumptions, the highest net savings are realised with option TL35 in both 2025 and 2030.

From the perspective of the truck operator, the cumulative net savings represent between 0.01 and 0.05 EUR per km in 2025 or 1% to 4% of the total operating costs depending the options considered. In 2030, the ranges are 0.04 to 0.10 EUR per km or 3% – 12% of the total operating costs.

**Figure 10: Net economic savings from a second use perspective in 2025 and 2030 (EUR/lorry)**



#### 6.2.4.2.4 Energy system impact

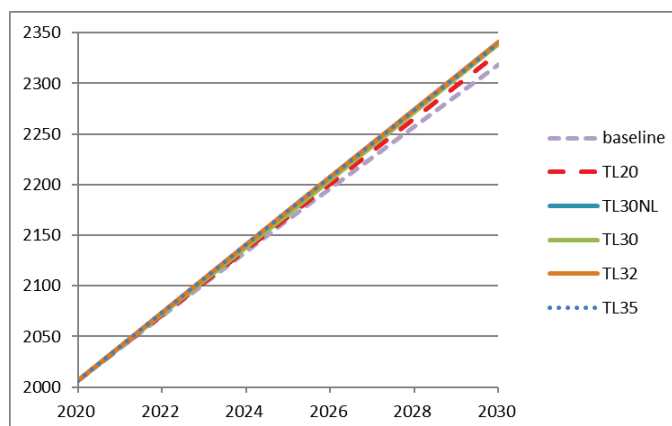
Across the different CO<sub>2</sub> target levels considered the final energy demand will be reduced compared to the baseline. For option TL30, the reduction is around 2 % and 5% by 2025 and 2030, respectively. In this way, HDV CO<sub>2</sub> targets would help improving the energy efficiency in the transport sector. In both years, diesel demand decreases with stricter targets, while LNG demand increases. The decreasing energy demand from diesel is larger than the increase for LNG.

Annex 10.7 provides more detailed information on the impact of the different TL options on the final energy demand for lorries in 2025 and 2030.

#### 6.2.4.2.5 Freight (HDV) transport impact

The freight transport activity is projected to increase slightly over time in the baseline scenario due to increased economic activity. The decrease in the fuel costs lowers freight costs, and consequently increases freight transport activity. However, as shown in Figure 11, for all the options assessed, this increase remains limited in the range of 0.2% to 0.4% in 2025 and 0.5% to 0.9% in 2030 depending on the target level option.

**Figure 11: Freight (HDV) transport activity (Gtkm) evolution in the period 2020-2030 under different target level options using the base cost assumptions**



Further analysis displayed in Annex 10.8 shows that the target levels have a limited impact on the reduction of the total costs of freight (HDV) transport per activity, by less than 1% in 2025 and in the order of 1 to 3% in 2030 depending on the target level. However, in turn, the reduction in transport costs will only lead to a minor increase in demand for transport services. These results are in line with the literature on the topic.<sup>58</sup>

Annex 10.8 illustrates how the different policy options have the potential to reduce the weight of fuel costs with respect to the total operating costs for a transport operator. Assuming that fuel costs in 2019 represent around a quarter of total operating costs, fuel savings could reduce total costs up to 5% in 2030 under the most ambitious target level option. The other costs would only increase slightly due to the cost of fuel-saving technologies. The overall impacts on the goods trade should therefore be limited.

#### 6.2.4.2.6 Macro-economic impacts

Table 4 shows the projected impact under the EXIOMOD model on GDP for the EU-28 of the target level options considered, compared to the baseline. The results show a small, almost negligible positive impact on EU-28 GDP under the five policy options considered, in both 2025 and 2030. In the projections, increased household expenditure and higher investment are associated with tighter CO<sub>2</sub> targets for HDV.

Impacts on the turnover of the most affected sectors are shown in Annex 10.7. Sectors associated to fossil fuels and petroleum products are projected to have a small decrease in turnover, which increases slightly with stricter CO<sub>2</sub> targets. The other sectors overall see small positive impacts, in particular freight and passenger services.

<sup>58</sup> See, for instance, Winebrake et al (2015); Dahl (2012); Matos and Silva (2011)

**Table 4: GDP impacts in the baseline (million euros) and percentage change from the baseline under the policy options**

<b>Option</b>	<b>2025</b>	<b>2030</b>
Baseline (M EUR)	14,447,916	15,397,847
TL 20	0.00%	0.03%
TL 30NL	0.01%	0.08%
TL 30	0.02%	0.09%
TL 32	0.02%	0.11%
TL 35	0.03%	0.14%

#### 6.2.4.2.7 *Impact on innovation and technological leadership*

The stricter the target level, the higher the incentive on HDV manufacturers and technology suppliers to innovate and develop more fuel-efficient technologies. A greater effort to innovate would translate into higher potential for technological development and better chances for EU HDV manufacturers to preserve their existing competitive edge on the world market.

#### 6.2.4.3 *Social Impacts*

As shown in Table 5, with stricter CO<sub>2</sub> target levels increasing economic activity, there is also a small increase of the number of jobs across the EU-28 compared to the baseline. The main drivers behind the GDP impacts also explain the induced employment impacts.

**Table 5: Total number of jobs (000s) under the baseline and percentage changes to the baseline under different policy options**

<b>Option</b>	<b>2025</b>	<b>2030</b>
<b>Baseline (000s)</b>	236,339	242,102
<b>TL20</b>	0.00%	0.02%
<b>TL30NL</b>	0.01%	0.04%
<b>TL30</b>	0.01%	0.05%
<b>TL32</b>	0.02%	0.06%
<b>TL35</b>	0.02%	0.08%

At sectoral level, the overall impacts are small. As shown in Annex 10.9, job losses are projected in the extraction of crude petroleum and manufacturing of refined petroleum products. Small positive impacts are seen for transport at higher target levels. The development of new fuel-saving technologies would only have a limited effect on the nature of the jobs in the HDV manufacturing sector and its suppliers. The need for reskilling and upskilling could be greater in the future with a larger scale deployment of zero- and low-emission vehicles in the HDV sector.

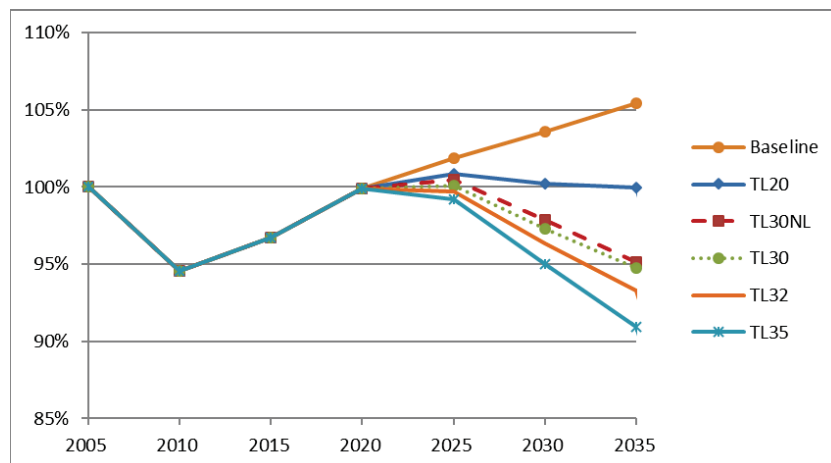
#### 6.2.4.4 *Environmental impacts*

##### 6.2.4.4.1 *CO<sub>2</sub> emission (tailpipe)*

The main environmental impact of setting the CO<sub>2</sub> targets for the new HDV fleet concern the tailpipe CO<sub>2</sub> emissions within the sector. Figure 12 shows the evolution of the tailpipe CO<sub>2</sub> emissions of HDVs (entire fleet, not only newly registered) between 2005 and 2035.

As shown in Annex 10.10, the cumulative HDVs CO<sub>2</sub> emission reduction compared to the baseline over the period 2020-2035 is estimated to range from 75,000 kt (TL20) to nearly 200,000 kt (TL35). As a matter of comparison, the Commission proposal setting new standards for cars and vans post-2020 would lead to a much higher cumulative CO<sub>2</sub> reduction of about 500,000 kt over the period 2020-2035. This is due to the fact that emissions from LDV are around four times larger than those of the four groups of lorries under consideration.

**Figure 12: (Tailpipe) CO<sub>2</sub> emissions of HDVs in EU-28 - % reduction compared to 2005 using the base cost assumptions**



#### 6.2.4.4.2 CO<sub>2</sub> emissions (WTW)

When considering the WTW CO<sub>2</sub> emissions, the trends are very similar as for tailpipe emissions. Under the baseline, emissions increase by around 4% between 2005 and 2030. Across the options considered, emissions in 2030 reduce from around 3% (TL20) to around 8% (TL35) with respect to the baseline.

#### 6.2.4.4.3 Air pollutant emissions

Both the reduction in overall fuel consumption and the shift to LNG lorries as the CO<sub>2</sub> targets get stricter also have a positive impact on air pollutant emissions. With the base cost assumptions, emissions of nitrogen oxides (NO<sub>x</sub>) from road transport are projected to be reduced, compared to the baseline, by 0.3% to 0.8% in 2025 and by 1.3% to 4.7% in 2030. Similarly, emissions of particulate matter (PM<sub>2.5</sub>) from road transport are estimated to be reduced by 0.1% in 2025 (for all target levels considered) and between 0.2% and 0.6% in 2030. The highest air quality co-benefits are achieved with the most ambitious CO<sub>2</sub> targets. This is further illustrated in Annex 10.10.

#### 6.2.4.4.4 Contribution to the Effort Sharing Regulation targets

Road transport is one of the sectors covered by the Effort Sharing Regulation (ESR). As shown by the EU Reference Scenario 2016<sup>59</sup>, further efforts are necessary to meet the EU's 2030 ESR target. The analytical work underpinning the ESR as well as the Energy Efficiency Directive proposals built on the so-called *EUCO30* scenario<sup>60</sup>, under which all 2030 climate and energy targets are met.

<sup>59</sup> <https://ec.europa.eu/energy/en/data-analysis/energy-modelling>

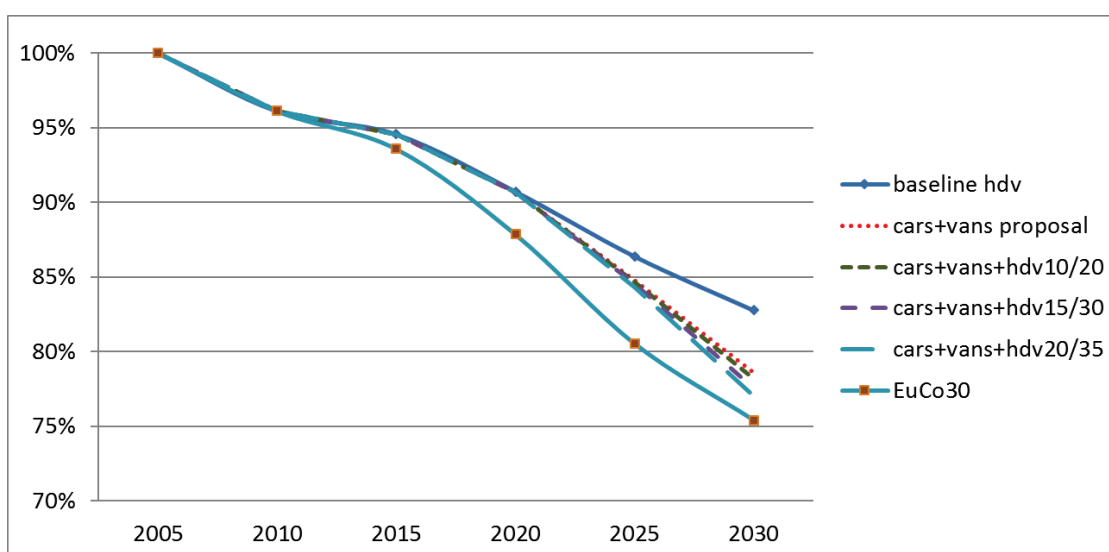
<sup>60</sup> The *EUCO30* scenario achieves the EU-wide 2030 targets for GHG emissions in the Effort Sharing Regulation (ESR) sectors (30% reduction compared to 2005), and for final energy supply (27% renewable energy and 30%

A consistency check was performed between the emission reductions under different CO<sub>2</sub> target level options considered in this Impact Assessment and those under *EUCo30*, taking into account also the 2017 Commission proposal for post-2020 CO<sub>2</sub> emission standards for new cars and vans.

Figure 13 depicts the projected GHG emissions from road transport under various scenarios. Under the *EUCo30* scenario, emissions are projected to reduce by 25% in 2030 with respect to 2005. Emission reductions are some 8 percentage points lower under the baseline. With the proposal for cars and vans, this difference gets significantly smaller, to 4 percentage points. The gap could be progressively closed with the implementation of CO<sub>2</sub> standards for lorries. Option TL20 would reduce the gap by about a quarter, while option TL35 would halve the gap.

Additional information is provided in Annex 10.12.

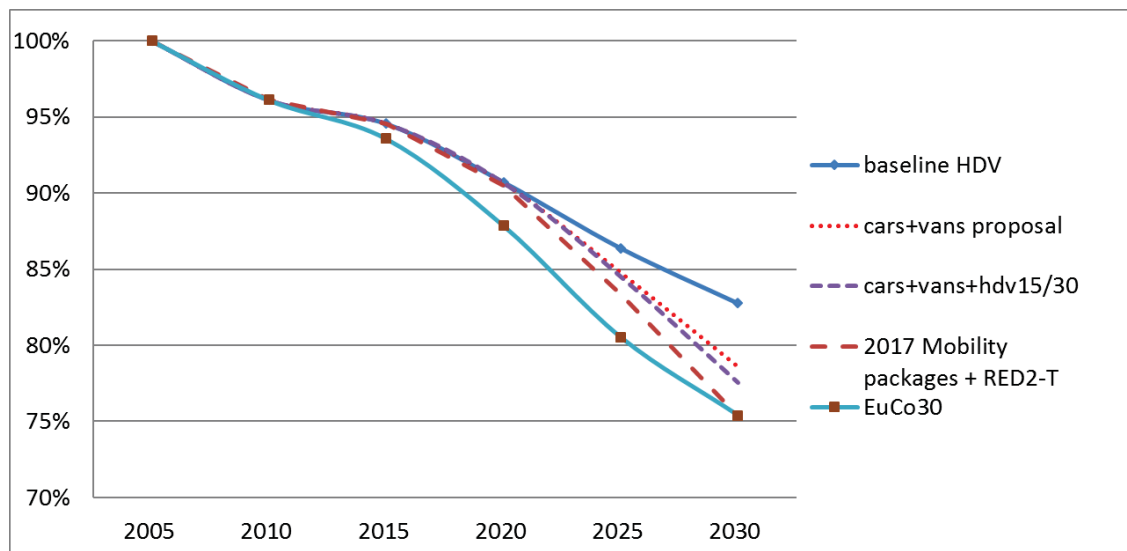
**Figure 13: Evolution of GHG emissions between 2005 (100%) and 2030 under the baseline and different policy options and in comparison with the *EUCo30* scenario**



Furthermore, the Commission proposed other additional policies with impacts on GHG road transport emissions. This concerns the minimum share of renewable fuels in transport as proposed by the Commission in the revision of the Renewable Energy Directive, as well as of the Eurovignette, Clean Vehicles and Combined Transport Directives. Figure 14 shows the projected GHG emissions from road transport in a scenario including also the proposal for CO<sub>2</sub> standards for cars and vans post-2020 as well as the option TL30 as regards the CO<sub>2</sub> emissions from heavy duty vehicles. The results are determined by the different sets of policies assumed in each scenario. It shows that the gap with respect to the EuCo30 scenario closes.

energy efficiency). It assumes the implementation of additional policies compared to the EU Reference scenario 2016. For the road transport sector, these additional policies included more ambitious CO<sub>2</sub> emission standards for new cars and vans.

**Figure 14: Evolution of GHG emissions between 2005 (100%) and 2030 under the baseline and different policy options and in comparison with the *EUCo30* scenario**



## 6.2.5 Timing

### 6.2.5.1 Target timing 1

Under this option, a single target would start to apply in 2025. For 2030, an aspirational target would be defined.

#### *Economic impacts*

This option would give sufficient lead time to manufacturers for gradually fitting the most cost-effective technologies to their new vehicles. The early uptake of fuel saving measures would lead to earlier net benefits for consumers and society, hence cumulative net savings would increase. Manufacturing costs could be reduced earlier as economies of scale could be reached earlier. EU manufacturers would be in a better position to preserve their innovation edge against global competitors.

The absence of a more stringent binding target after 2025 could create uncertainty for manufacturers as they would lack a longer term perspective for the deployment of technologies improving vehicle efficiency. This uncertainty could be mitigated by an early review to confirm the level of a binding target for 2030.

#### *Social impacts*

There is no particular social impact for this option.

#### *Environmental impacts*

This option provides for early action as a 2025 target could potentially lead to a steeper emission reduction trajectory in the period up to 2025. The sooner the CO<sub>2</sub> emission target comes into force, the higher the cumulative emission reductions by 2030.

It will also reassure Member States that will have binding reduction targets for every year from 2021 until 2030 under the Effort Sharing Regulation that the HDV sector will contribute a specific share of reductions.

The absence of a more stringent binding 2030 target may initially slow down emission reductions after 2025, but this could be mitigated by defining an aspirational target combined with an early review to confirm it.

#### 6.2.5.2 *Target timing 2*

Under this option, a first CO<sub>2</sub> reduction target will start to apply in 2025 followed by a stricter one introduced as of 2030.

##### *Economic Impact*

Setting CO<sub>2</sub> emission reduction targets in 2025 and 2030 would provide both an early and a medium-term signal for the HDV sector to deploy more fuel-efficient technologies over the next 15 years. Setting a mandatory 2030 target at this stage, given the lack of robust information on how technology performance and costs might evolve, bears the risk that the target is not set at the most cost-effective level. It will therefore be necessary to review the 2030 CO<sub>2</sub> emission targets in 2022 once sufficient certified CO<sub>2</sub> emission data have been collected.

Transport operators would benefit from fuel cost savings from the early 2020s on due to an earlier introduction of more efficient HDVs driven by a first target starting to be applicable in 2025.

A stricter target introduced in 2030 would provide a strong signal to the market of the need to invest in research and development.

##### *Social impacts*

There is no particular social impact for this option.

##### *Environmental Impact*

With the introduction of a 2025 target, this option provides for early action well ahead of 2030 while at the same time providing for a longer term emission reduction trajectory. As a result, cumulative emission reductions are expected to increase.

#### 6.2.5.3 *Target timing 3*

Under this option, a single CO<sub>2</sub> emission target would start to apply in 2030.

##### *Economic Impact*

Applying a first target in 2030 only would allow manufacturers to postpone investments in new technologies. While this might be perceived as reducing costs in the short term, it could have a negative impact on the technology cost reduction over time by not realising early economies of scale.

Secondly, such delay will lower the rate of innovation over the next years and risks maintaining the current low market deployment of new technologies. Given the regulatory situation and evolution in other regions in the world, EU manufacturers could risk losing their technological leadership position.

Thirdly, from a consumer, transport operator and societal perspective, economic benefits would be foregone as the net savings delivered by lower fuel costs would not materialise in the next years.

This option increases the risk for EU manufacturers to lose their current position of technological leadership as delaying the entry into force of a binding target would not promote innovation in the coming decade.

### *Social impacts*

There is no particular social impact for this option.

### *Environmental Impact*

Even if a 2030 target may be expected to create some anticipation by manufacturers, the absence of a binding CO<sub>2</sub> target prior to 2030 is very likely to cause a number of technologies to be introduced only close to the date of application of the CO<sub>2</sub> reduction target, in particular for those technologies with higher manufacturing costs.

Furthermore, given the average lifetime of new vehicles, cumulative emissions would increase and this effect would persist in the years after 2030.

## **6.3 Distribution of EU fleet-wide CO<sub>2</sub> emission target across vehicle groups and manufacturers**

### *6.3.1 Option Distribution 1: Separate targets per HDV sub-group*

Under this option, the CO<sub>2</sub> reduction targets (in percentage) would differ across the sub-groups covered, based on an overall cost minimisation. Each of those targets (up to eight in case of option Scope 1) would apply for each manufacturer. The analysis found that the reduction targets derived this way would actually differ very little amongst the sub-groups, so this option would yield almost the same outcome as option Distribution 2 as far as the sub-group targets are concerned.

### *Economic Impact*

As the sub-group targets set under this option would reflect the minimal total costs across all HDVs covered, the economic impacts of this option would in principle be optimal.

However, this would only be the case if the cost assumptions would be perfectly known in advance, and the fleet composition used for deriving the targets would effectively materialise and not significantly vary over time. Relative changes in costs or fleet composition would lead to a sub-optimal outcome in terms of overall costs as under this option there would be no opportunity for manufacturers to compensate an underperformance in one sub-group with an overachievement in others.

### *Social Impact*

There is no particular social impact for this option.

### *Environmental Impact*

For a given transport activity level, the actual target levels and the evolution of the fleet composition would be the main determining factor for the environmental impact. Setting different reduction targets for each sub-group would not affect the overall environmental outcome, nor would the fact that the sub-group targets apply for each manufacturer.

### *Other considerations*

Setting eight different emission targets for each manufacturer does not offer any flexibility in terms of implementation. The implementation of eight sub-targets could be administratively more burdensome, in particular in view of the rather limited number of vehicles registered annually per manufacturer within some of the sub-groups. For manufacturers it might be more cost-effective to pay the penalty for non-compliance than to make the effort to reduce emissions for a small number of lorries.



### 6.3.2 Option Distribution 2: Single target per manufacturer

Under this option, the same emission reduction target (in percentage) would be applicable for all sub-groups covered, and this would be translated into a single target for each manufacturer, calculated as the weighted average of all sub-group targets, taking into account the number of vehicles and their utility.

#### *Economic Impact*

Due to the technical differences between the sub-groups, as reflected in the cost-curves, equal sub-group reduction targets could lead to different technology costs across the sub-groups. However, as confirmed by the analysis of option Distribution 1, equal sub-group targets would reflect a nearly optimal distribution of the overall costs across the HDV fleet. In addition, a further cost optimisation at manufacturer level would be possible due to the additional flexibility offered by the single specific target value. This would allow manufacturers to compensate non-compliance with one sub-group target by overachieving the target for another sub-group.

Since fuel consumption is proportional to CO<sub>2</sub> emissions, the flexible accounting across sub-groups would reward a higher uptake of emission reducing technologies in sub-groups with a high average transport utility, i.e. a high fuel consumption during its lifetime. In general, this is in the interest of the customer and society.

This option would provide flexibility for manufacturers to optimise their vehicle portfolio across sub-groups to customer demand and future technical developments.

#### *Social Impact*

There is no particular social impact for this option.

#### *Environmental Impact*

Setting the same reduction targets for each sub-group does not *per se* affect the overall environmental outcome of the policy, as this will be determined – for a given transport activity level - by the actual target level applied and by the evolution of the fleet composition.

The flexibility of applying a single average target for each manufacturer would be environmentally neutral as long as it can be ensured that the total lifetime CO<sub>2</sub> emissions of the vehicle fleet do not increase. This would be achieved by the weighting of the sub-group targets on the basis of the number of vehicles in each sub-group and their utility.

## **6.4 Incentives for Zero- and Low-Emission Vehicles (ZEV/LEV)**

Targeted ZEV/LEV incentives should help the HDV sector and public authorities in developing an EU market for these vehicles fostering the required investments in fuel efficient vehicle technologies.

Reliable cost data for ZEV/LEV are currently very scarce<sup>61</sup> and do not allow for robust cost projections in the short and medium term. For electric lorries, the main incremental

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<sup>61</sup> An overview of projected costs gathered from literature is given e.g. in ICCT (2017) Transitioning to zero-emission heavy-duty freight vehicles. (M. Mourtak, N. Lutsey, D. Hall) and in IEA/OECD (2017) The Future of Trucks - Implications for energy and the environment (<https://www.iea.org/publications/freepublications/publication/TheFutureofTrucksImplicationsforEnergyandtheEnvironment.pdf>)

cost is the cost of battery packs, which has recently been rapidly decreasing<sup>62</sup>. As regards lorries using catenary systems, electric road systems (ERS), which build upon a mainstream technology adopted in many cities for buses, require high investments.

Given the lack of robust cost data, only a qualitative assessment of the impacts of the various options considered is currently possible. It is expected that more reliable cost data will become available by 2022 once the development and deployment of these vehicles advances in the next years.

#### *Economic impacts*

As regards the two options concerning the scope of the incentive, covering either ZEV only or both ZEV and LEV, the economic impacts would be quite similar for both of them, especially when compared to the impacts of the other design elements, e.g. the super –credit multiplier and the caps.

The following considerations can be made as regards the economic impacts of the options considered for the type and level of incentive:

<i>Option</i>	<i>Economic Impacts</i>
1. Super-credits	<ul style="list-style-type: none"> <li>- manufacturing / capital costs: Reduction of costs for manufacturers as the measure is not binding and allows manufacturers to optimise their fleet composition to meet the target.</li> <li>- fuel savings: Risk for reduced fuel savings for the average vehicle in case of a weakening of the target and a deployment of less efficient ZEV/LEV. This risk would be limited by (i) the low expected share of ZEV/LEV; (ii) a low multiplier and (iii) the cap to limit the weakening of the target.</li> </ul>
2. One-way crediting system	<ul style="list-style-type: none"> <li>- manufacturing / capital costs: similar as for option 1.</li> <li>- fuel savings: similar as for option 1. Risk is even lower as target relaxation is only granted to manufacturers exceeding the benchmark level and in relation to the excess share of ZEV/LEV.</li> </ul>
3. Two-way crediting system	<ul style="list-style-type: none"> <li>- manufacturing / capital costs: Impact will depend on the feasibility for manufacturers (on average) to meet the benchmark. If the benchmark is too strict, the targets would be tightened and this would cause costs to increase. In the other case, a small decrease of costs is likely to occur in view of the target relaxation.</li> <li>- fuel savings: Same considerations as for costs, but with opposite effect, i.e. high likelihood of more fuel savings in case of a too strict benchmark.</li> </ul>
4. Binding mandate	<ul style="list-style-type: none"> <li>- manufacturing / capital costs: Same considerations as for option 3. A too strict mandate would lead to penalties for manufacturers.</li> <li>- fuel savings: same considerations as for costs, but with opposite effect, i.e. more fuel savings in case of stricter benchmark.</li> </ul>
Variant – opt-in for zero-emission buses and small lorries	<ul style="list-style-type: none"> <li>- manufacturing / capital costs: Reduced costs for manufacturers, as this option provides additional possibilities to optimise the fleet composition in view of meeting the target.</li> <li>- fuel savings: Increased risk of reduced fuel savings</li> </ul>

<sup>62</sup> This is extensively documented in SWD(2017) 650 final (8.11.2017)

	- competition impacts: Risk of creating a competitive distortion among lorry manufacturers, as only some of them are also manufacturing buses. Also risk of creating a competitive distortion for manufacturers producing buses only, as those would not receive such incentives as compared to operators in the HDV sector.
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Incentivising the development of ZEV/LEV would help stimulating innovation in the HDV sector and EU automotive industry to safeguard its technological leadership position.

*Energy system impacts*

Based on the findings for cars/vans<sup>63</sup>, where projected uptake of electric vehicles is much higher than in the case of HDV, it can be safely assumed that the increased market penetration of electrically chargeable HDV would not significantly change the share of electricity in the final energy demand for transport by 2025.

*Social Impacts*

No significant social impacts are expected.

*Environmental impacts*

The impacts on CO<sub>2</sub> emissions are mainly determined by the EU-wide fleet CO<sub>2</sub> target, to which the ZEV/LEV incentive would be a complementary measure. Therefore, it may be generally expected that the scope, the type and the design of the incentive mechanism would have limited environmental consequences.

Option Scope 1 (ZEV only) would ensure that the uptake of vehicles contributing most to the emission reductions is incentivised. While in the short term this may weaken the targets a bit more, it would provide a stronger signal towards the future need for a higher share of ZEVs to reach the longer-term objectives.

Option Scope 2, allowing also LEV to be incentivised, could smoothen the transition towards zero-emission mobility, even though it is currently unclear to what extent manufacturers are advancing with the development and deployment of such LEV. Granting credits on the basis of the emissions of the LEV provides an incentive for improving LEV CO<sub>2</sub> performance, while mitigating the risk of weakening the targets for the sake of achieving limited environmental benefit.

The following considerations concern the options regarding the type of incentive:

Option	<i>Environmental impacts - CO<sub>2</sub> emissions (tailpipe)</i>
1. Super-credits	Counting ZEV/LEV as more than one vehicle in principle creates a risk of weakening the overall CO <sub>2</sub> target as it allows emissions of other HDVs to increase <sup>64</sup> . However, this weakening would be limited by (i) the low expected share of ZEV/LEV; (ii) a low multiplier and (iii) the cap to limit the weakening of the target.
2. One-way crediting	Similar considerations as for option 1, albeit to a lesser extent, as a target relaxation would only be granted to those manufacturers

<sup>63</sup> SWD(2017) 650 final

<sup>64</sup> Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO<sub>2</sub> emissions from light-duty vehicles, available at: [https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation\\_ldv\\_co2\\_regs\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf)

system	exceeding the benchmark level and in relation to their excess share of ZEV/LEV. The cap would avoid extensive target weakening.
3. Two-way crediting system	The impacts will depend on the ZEV/LEV uptake by manufacturers. In case all manufacturers would overachieve the benchmark, considerations are identical as for option 2. However, in all other cases the risk for target relaxation is mitigated as those manufacturers not meeting the benchmark share of ZEV/LEV will need to meet a stricter CO <sub>2</sub> target.
4. Binding mandate	No negative environmental impact as the mandate will act as an additional requirement, leaving the overall CO <sub>2</sub> target unaffected.
Variant – opt-in for zero-emission buses and small lorries	This creates a further risk for lowering the amount of CO <sub>2</sub> emission reductions achieved by the policy and this for all of the above options. Incentivising HDVs, which are not subject to the CO <sub>2</sub> target, will reduce the need to lower the emissions from the HDVs within the scope. While the caps will limit this negative impact, it is more likely under this variant that the cap would be "filled" by allowing more vehicle types to be eligible. The net environmental impacts of this variant will depend on whether or not the incentive would lead to more zero-emission buses and small lorries compared to the baseline situation.

## 6.5 Elements for Cost-Effective Implementation (Flexibilities)

### 6.5.1 Exemption of vocational vehicles

#### *Economic Impact*

Due to their lower mileage and payloads compared to other HDVs, vocational vehicles have a more limited cost-effective CO<sub>2</sub> emission reduction potential. Exempting these vehicles from the scope could thus avoid disproportionately high compliance costs for the manufacturers concerned.

#### *Social Impact*

There were no relevant social impacts of this option identified.

#### *Environmental Impact*

By allowing some vehicles not to be subject to the CO<sub>2</sub> reduction requirements, this option may result in lower CO<sub>2</sub> emission reductions and hence decrease the effectiveness of the policy. However, by targeting a group of vehicles with a rather low annual mileage and restricting the share of vehicles which may be exempted, the environmental benefits foregone would be limited.

### 6.5.2 Flexibilities across manufacturers

#### 6.5.2.1 Pooling

#### *Economic Impact*

Pooling can reduce overall compliance costs for manufacturers. Instead of meeting a specific emissions target individually, pooling allows manufacturers to specialise by sharing and lowering compliance costs. Experience under the LDV Regulations has shown that pooling may be an important flexibility, which has improved the cost-effectiveness of the Regulations.

However, the situation is different in the HDV sector where pooling could limit technological competition between the already limited number of individual manufacturers and foster concentration on a limited range of CO<sub>2</sub> reduction technologies. That would lead to a narrower product range of technological options available on the market and slow down innovation. Thus, from a perspective of an individual manufacturer, while pooling might pay off in the short term through lower manufacturing costs, it could be risky if it stalls innovation in fuel efficiency.

#### *Social Impact*

There were no relevant social impacts of this option identified.

#### *Environmental Impact*

While pooling may negatively affect the level of investment in CO<sub>2</sub> reducing technologies by individual manufacturers, it should not negatively affect the achievement of the fleet-wide CO<sub>2</sub> emission reduction target.

#### *Administrative burden*

Pooling would increase the administrative burden as applicable rules and conditions would need to be set out and applied by the manufacturers pooling among each other.

### 6.5.2.2 *Trading*

#### *Economic Impact*

Trading can reduce overall compliance costs for manufacturers by providing for flexibility in meeting the targets. This in turn may create an additional revenue stream.

Compared to pooling, trading does not require an upfront decision on whom to share reduction efforts with as it could practically only take place after manufacturers are informed about the provisional calculations of their target compliance. This would allow manufacturers to trade the exact amount of credits needed to meet their target before the confirmation of the final compliance data.

A manufacturer or pool that over-complies with its target and has therefore invested in more efficient vehicles can sell credits and generate additional revenue to recover its additional investment costs, at least partially. At the same time, for another manufacturer or pool it may be cheaper to buy credits than putting additional investments in new technologies or paying penalties.

These benefits depend on the liquidity in the market and the willingness of manufacturers to trade. Given the small number of manufacturers, a few of them may dominate the market and this could have negative effects on competition, hampering rather than accelerating technology development. This may limit the economic benefits of trading.

During the public consultation, some stakeholder groups supported trading as it would decrease compliance costs. Manufacturers did not support this option.

#### *Social Impact*

There were no relevant social impacts of this option identified.

#### *Environmental Impact*

Trading should not negatively affect the achievement of the EU-wide fleet CO<sub>2</sub> targets. A trading mechanism may affect the level of investment in new technologies by each specific manufacturer (or pool). Without a trading mechanism, each manufacturer (or

pool) would have to have a certain number of energy-efficient vehicles in its fleet in order to comply with the set targets.

By contrast, under a trading mechanism, a manufacturer could decide to invest less in new technologies and instead buy credits from other manufacturers to fulfil the CO<sub>2</sub> target. Investments in energy-efficient vehicles and/or ZEV/LEV may be limited to only some specialised manufacturers (or pools) and hence possibly limit the number of manufacturers taking up innovative technologies.

#### *Administrative burden*

This option would increase administrative costs. It would require both manufacturers and the Commission to monitor all transactions, e.g. in the form of a register.

### *6.5.3 Flexibilities across different target years*

#### *6.5.3.1 Target compliance 1: annual compliance assessment*

##### *Economic Impact*

An annual compliance option limits the flexibility for HDV manufacturers to develop and market new technologies, and thus to comply with the CO<sub>2</sub> emission targets. It may therefore increase compliance costs. In the initial years, this option could also restrict the lead time available for some HDV manufacturers to develop the technologies necessary to comply with the CO<sub>2</sub> emission target. In view of the long development cycle for HDVs, this option may unnecessarily penalise manufacturers who experience minor delays in bringing the target-compliant HDV models to the market.

##### *Social Impact*

There are no direct or otherwise relevant social impacts of this option.

##### *Environmental Impact*

By strictly adhering to a certain annual emission level this option reinforces the certainty of accomplishing the CO<sub>2</sub> emission target.

#### *6.5.3.2 Target compliance 2: banking and borrowing*

##### *Economic Impact*

Allowing the banking and borrowing of credits offers manufacturers greater flexibility and can therefore increase the overall cost-effectiveness of the policy.

Banking rewards early movers and helps to alleviate efforts at a later stage, which may be generally more expensive or require a more advanced shift in fuel-efficient technologies. It would allow for managing unexpected annual fluctuations in a manufacturer's fleet without falling into non-compliance.

A particular downside as regards borrowing could arise in case a manufacturer that has been borrowing credits to be reimbursed in future compliance periods would go out of business. This would create problems of liability for compensating the credit deficit for that period. This risk would be addressed by limiting the borrowing to 5% of the specific emissions target.

##### *Social Impact*

There are no direct or otherwise relevant social impacts of this option.

##### *Environmental Impact*

Banking poses the risk that accumulating and carrying over of credits can undermine the effectiveness of the CO<sub>2</sub> reduction target in the medium to long-term. If that risk materialises, negative effects on the environment cannot be excluded.

Borrowing also implies the risk of a negative impact on environment. When borrowing, manufacturers may not be able to balance a negative amount of credits at the end of the implementation period, e.g. when going out of business.

Nevertheless, mitigating measures exist to limit the negative environmental effects. In the option considered and described in Section 5.4.3 and Annex 9.4, several parameters have been introduced to limit this risk. This concerns the definition of the trajectory against which credits/debits will be generated and limiting the use of credits to one compliance period without the possibility of carry-over into the next period.

#### *Administrative burden*

The introduction of banking and borrowing would increase administrative costs as it would require tracking of the credits and debits. However, this would not be excessive as the number of market participants is very small.

## **6.6 Governance**

### *6.6.1 Real-world emissions*

#### *6.6.1.1 Option 1: Collection, publication, and monitoring of real world fuel consumption data reported by manufacturers using currently available devices*

##### *Economic Impact*

The economic impact of this option is mainly associated to the administrative burden to establish and operate a monitoring mechanism, which will strongly depend on its actual design.

##### *Social Impact*

There is no significant social impact due to this option.

##### *Environmental Impact*

Regular monitoring of real-world fuel consumption data and the possibility to make it publicly available would provide a basis for cross-checking the representativeness of certified CO<sub>2</sub> emission data. This would allow to identify corrective actions limiting the possible growth of a gap between certification and real-world CO<sub>2</sub> emission values.

Availability and public access to real world fuel consumption and CO<sub>2</sub> emission data could increase market transparency, which may in turn stimulate the market up-take of CO<sub>2</sub> reducing technologies.

The environmental effectiveness of the option depends on the quality of the available data, which may be undermined in the absence of standardised measurement devices.

#### *6.6.1.2 Option 2: Collection, publication, and monitoring of real world fuel consumption data reported by manufacturers using mandatory standardised fuel consumption monitoring devices*

##### *Economic Impact*

If the standardised measurement devices would become mandatory in new HDVs through type approval, the Commission could propose to retrieve such data for example

by means of reporting or publication obligations for manufacturers, periodic or ad-hoc inspections, remote sensing or a combination thereof. This would be subject to a dedicated analysis and assessment to underpin new regulatory provisions on this issue.

Alternatively, ad hoc periodic test campaigns covering representative fleet samples could be carried out. In this case, the Commission would carry out internal and external specific studies.

#### *Social Impact*

There is no relevant social impact associated with this option.

#### *Environmental Impact*

This option would allow for a robust monitoring of real-world CO<sub>2</sub> emission data. The standardised nature of the measurement devices would ensure comparability of the monitored emission data and provide for a solid basis for verifying the certified emission data. The better quality of the available data will make the CO<sub>2</sub> emission reduction target more effective with a positive effect on the environment.

The availability of public access to real world fuel consumption and CO<sub>2</sub> emission data would increase market transparency, which may in turn stimulate the market up-take of CO<sub>2</sub> reducing technologies.

### *6.6.2 Market surveillance*

#### *6.6.2.1 Option 1: Introduce in-service conformity tests, the obligation to report deviations and the introduction of a correction mechanism*

#### *Economic Impact*

The requirement for national authorities to carry out in-service conformity tests and to report to the Commission any deviations found would allow the Commission to take further steps in ensuring that such deviations are penalised and remediated. This would prevent the distorting effect such deviations may have on the competition among different manufacturers.

It would also create a strong deterrent from placing vehicles on the market with deviating CO<sub>2</sub> and fuel consumption values. It could be expected that the mere possibility of being subject to corrections of the CO<sub>2</sub> monitoring data would in itself reduce the risk for such deviations occurring systematically.

This option would incur an administrative burden on type approval authorities. However, it can be assumed that the data concerned will also be documented and reported for the purpose of the type approval legislation.

#### *Social Impact*

There is no relevant social impact associated with this option

#### *Environmental Impact*

This option should contribute to ensuring reliable and representative CO<sub>2</sub> data to be made available. This would lead to improving the effectiveness of the CO<sub>2</sub> emission standards by ensuring that the CO<sub>2</sub> reductions foreseen are actually achieved.

### *6.6.3 Penalties*

#### *Economic Impact*



The economic impact of financial penalties will depend on the target level set as this influences the marginal technology costs.

As illustrated in Annex 10.13, a penalty level of €570 per g CO<sub>2</sub>/km, which is the equivalent of the currently applicable penalty under the LDV Regulations (see Section 5.5.3) would exceed the marginal technology costs in the HDV sector for most target level options. However, in 2030, for the most ambitious target levels considered, a higher penalty level would be required to ensure sufficient incentives are provided for manufacturers to invest in new cost-effective technologies.

#### *Social Impact*

There are no direct or otherwise relevant social impacts of this option.

#### *Environmental Impact*

As long as the penalties are higher than the marginal costs of the new technologies needed to meet the CO<sub>2</sub> target, the penalties are a deterrent for non-compliance. In that case, setting a penalty will ensure that emissions are effectively reduced.

## **7 COMPARISON OF OPTIONS**

The options considered are compared against the following criteria:

- **Effectiveness:** the extent to which different options would achieve the objectives;
- **Efficiency:** the benefits versus the costs; i.e. "the extent to which objectives can be achieved for a given level of resource/at least cost".
- The **coherence** of each option with the overarching objectives of EU policies; ;
- The compliance of the options with the **proportionality principle**

The effectiveness of the policy options considers the extent to which the set objectives as presented in Chapter 4 are achieved.

While CO<sub>2</sub> emission standards for lorries are a key element to achieve the objectives, they cannot deliver them on their own. A number of other complementary policy measures – both on the supply and demand side – have already been or need to be put in place at EU and national level.

These include procedures for certifying CO<sub>2</sub> emissions and fuel consumption (HDVs certification legislation, VECTO), policies supporting the internalisation of external costs linked to emissions (Eurovignette Directive), development of new technologies through research, deployment of low-emission HDVs through public procurement (Clean Vehicles Directive), investment in the necessary refuelling/recharging infrastructure (Alternative Fuels Infrastructure Directive), and policies and measures to improve energy efficiency and the use of low-carbon fuels (Renewable Energy Directive) (see Section 2.3 and Annex 6.2 for more details).

**Table 6: Comparison of the options considered against the key criteria**

<b>Assessment of expected impacts – legend</b>				
xx	x	O	✓	✓✓
Strongly negative	Weakly negative	No or negligible impact	Weakly positive	Strongly positive
<i>Options considered</i>	<i>Effectiveness</i>	<i>Efficiency</i>	<i>Coherence</i>	<i>Proportionality – added value</i>
<b>1. EMISSION TARGETS</b>				
<b>1.1. SCOPE</b>				
Groups 4, 5, 9 and 10 whole-vehicle CO <sub>2</sub> standards	✓✓	✓✓	✓	✓
Group 5 whole-vehicle CO <sub>2</sub> standards	✓	✓	✓	✓
Additional engine-only CO <sub>2</sub> emissions standards	✓	x	O	x
<i>Options considered</i>	<i>Effectiveness</i>	<i>Efficiency</i>	<i>Coherence</i>	<i>Proportionality – added value</i>
<b>1.2. METRIC</b>				
Tank-to-Wheel	✓	✓	✓✓	✓✓
Well-to-Wheel	x	x	xx	xx
<b>1.3. METRIC UNIT</b>				
g CO <sub>2</sub> /km	✓	✓	O	O
g CO <sub>2</sub> /tkm	✓	✓	✓	✓
g CO <sub>2</sub> /m <sup>3</sup> km	✓	O	O	O
<b>1.4. CO<sub>2</sub> TARGET LEVEL</b>				
TL 20	✓	✓	O	✓✓
TL 30NL (Non Linear)	✓✓	✓✓	✓✓	✓✓
TL 30	✓✓	✓✓	✓✓	✓✓
TL 32	✓✓	✓	✓	✓
TL 35	✓✓	✓	O	x
<b>1.5. TIMING</b>				
CO <sub>2</sub> target in 2025 and aspirational target in 2030	✓✓	✓✓	✓✓	✓
CO <sub>2</sub> targets in 2025 and in 2030	✓✓	✓✓	✓✓	✓
CO <sub>2</sub> targets in 2030	O	O	O	✓
<b>2. DISTRIBUTION OF EU FLEET-WIDE CO<sub>2</sub> EMISSION TARGET LEVEL</b>				
Different emission reduction target per sub-group / eight targets per manufacturer	✓	x	✓	x
Same emission reduction target for all sub-groups / one target per manufacturer	✓	✓✓	✓	✓✓
<b>3. ZEV / LEV INCENTIVES</b>				
Super-credits	✓	✓✓	✓✓	✓
One-way crediting system	✓	✓	✓	✓
Two-way crediting system	✓	x	O	x
ZEV/LEV mandate	✓	x	O	x

<i>Options considered</i>	<i>Effectiveness</i>	<i>Efficiency</i>	<i>Coherence</i>	<i>Proportionality – added value</i>
Count ZEV/LEV HDV outside the scope of the targets	✓	✓	0	0
<b>4. ELEMENTS FOR COST-EFFECTIVE IMPLEMENTATION</b>				
<b>4.1. EXEMPTIONS</b>				
Exempt vocational vehicles	0	✓	0	✓
<b>4.2. FLEXIBILITIES ACROSS MANUFACTURERS</b>				
Pooling	0	✓	x	x
Trading	0	✓	x	x
<b>4.3. FLEXIBILITIES ACROSS DIFFERENT TARGET YEARS</b>				
Annual compliance assessment	✓	✓	✓	0
Banking and borrowing	0	✓✓	✓	✓
<b>5. GOVERNANCE</b>				
<b>5.1. REAL-WORLD EMISSIONS</b>				
Monitoring of real world fuel consumption data using currently available devices	✓	0	✓	0
Monitoring of real world fuel consumption data using standardised devices	✓✓	✓✓	✓	✓
<b>5.2. MARKET SURVEILLANCE</b>				
Reporting of deviations found during in-service conformity tests and correction mechanism for monitoring data	✓✓	✓✓	✓	✓
<b>5.3. PENALTIES</b>				
Financial penalties to ensure compliance with CO <sub>2</sub> emission standards	✓✓	✓✓	✓	✓✓

## 7.1 Emission target

### 7.1.1 Scope

Options 1 and 2 set whole-vehicle standards only for the main vehicle groups, with option 1 covering the four main groups and option 2 covering only the largest one. The main distinction between the impacts of these two options lies in their scale.

By covering some 65% to 70% of total HDV CO<sub>2</sub> emissions, option 1 is more effective than option 2 in achieving the objective related to the reduction of CO<sub>2</sub> emissions. It would also benefit a larger number of transport operators in terms of reduction of fuel costs. It would also incentivise innovation in a larger number of vehicles. Thus, option 1 is more effective in reaching all the specific objectives.

The applicable emission reduction technologies are largely similar for the different vehicle groups, meaning that technology costs do not differ much across the groups. Spreading those costs over a larger number of vehicles will therefore allow for realising economies of scale, and thereby reduce the average compliance costs. As a consequence, option 1 should be the cost efficient option.

Both options 1 and 2 are coherent with the overarching EU policy objectives and are proportionate as they target the main vehicle groups within the sector.

Under option 3, engine-only CO<sub>2</sub> standards would be set in addition to the whole-vehicle standards foreseen under options 1 and 2. The whole-vehicle standards in fact already include engine emissions as these are captured by the VECTO simulation tool. In case the whole-vehicle standards are properly defined, complementing them with engine only standards would increase administrative burden and compliance costs without significant additional environmental benefit. Consequently, option 3 scores worse in terms of efficiency, while not being more effective. As the engine-only standards risk being incoherent with the whole-vehicle standards, it also scores lower in terms of coherence and proportionality – added value.

Stakeholders generally supported option 1, except for some environmental NGOs, who favoured option 3.

### *7.1.2 Metric*

As described in Chapter 6, key distinctions between the TTW and WTW options considered lie in their differences in coherence with other policies and in additional complexity and administrative burden they might cause.

The WTW approach presents implementation difficulties as WTT emissions are not a property of the vehicle but depend on the fuel used. It would be very difficult to establish an adequate target value and it would lead to confusion of responsibilities and liabilities by making manufacturers accountable for emissions occurring outside their sector.

By focusing on the vehicle's CO<sub>2</sub> efficiency, the TTW approach is considered fully coherent with the other policy instruments contributing to the EU's climate and energy policy. It is also more effective in addressing the objectives of reducing fuel costs for transport operators and for promoting technological innovation.

On the contrary, a WTW metric could lead to double regulation interfering with the EU ETS and the low-emission fuels policy, in particular the Commission's RED-II proposal. There is even a risk that a WTW approach could undermine the environmental effectiveness of EU legislation as emission reductions already counted under RED-II would also be counted under the vehicles legislation, i.e. representing double counting. This would make it difficult for Member States to estimate the total amount of emission reductions in the transport sector stemming from RED-II and the improvements in HDV CO<sub>2</sub> efficiency improvements, particularly as the consumption of biofuels is not evenly distributed among Member States.

In order to maintain the cumulative environmental ambition of the two legislative acts, a WTW approach would require more stringent target levels in the vehicle emissions legislation in order to take account of the significant emission reductions that would be counted twice.

Only a few stakeholders from the fuels and gas sector supported a WTW approach during the open public consultation.

### *7.1.3 Unit metric*

The three options on the unit metric for the whole-vehicle standards differ in the extent to which they reflect the nature of transport utility and the possibility they offer for comparison between CO<sub>2</sub> emissions in light duty and heavy-duty sectors.

Using the unit g CO<sub>2</sub>/km makes it easy to compare the CO<sub>2</sub> emissions in light-duty and heavy-duty sectors because it is the unit metric used to measure CO<sub>2</sub> emission reductions in the case of cars and vans.

The units g CO<sub>2</sub>/km and g CO<sub>2</sub>/m<sup>3</sup>km do not fully reflect the transport utility of HDVs in terms of mileage travelled and the mass of goods actually transported. The only unit metric that does so is the one expressed in g CO<sub>2</sub>/tkm which therefore scores more positively in terms of coherence and added value. However, the choice of the unit metric is mainly a question of presentation.

Stakeholders representing vehicle manufacturers, automotive component suppliers and the gas sector expressed a preference for a g CO<sub>2</sub>/tkm unit, while most civil society organisations preferred expressing the targets in g CO<sub>2</sub>/km.

#### *7.1.4 Target levels*

The options considered cover a range of CO<sub>2</sub> reduction target trajectories up to 2030.

An analysis of the cost-effective technologies already at hand or becoming readily available in the short term shows that their full deployment would allow achieving emission reductions between 15% to 20% in 2025 compared to the baseline.

Higher uncertainties over the performance and costs of more advanced technologies and, in particular, alternative powertrains relying on the existence of an alternative fuels infrastructure could affect the feasibility of higher target level options in 2030.

The stricter the target levels, the higher their effectiveness in achieving the specific objective of reducing CO<sub>2</sub> emissions and in addressing the market uncertainties and inertia in the HDV market in deploying readily available fuel saving technologies and in investing in new technologies. Across the options considered, emission reductions from the entire HDV fleet in 2030 range from around 3% (TL20) to around 8% (TL35) compared to the baseline.

The co-benefits in terms of reduced air pollution also increase with the stringency of the target leading to additional reductions of NO<sub>x</sub> and PM<sub>2.5</sub> emissions by 2030 compared to the baseline. The improvements range from 1.3 percentage points (TL20) to 4.7 percentage points for NO<sub>x</sub> (TL35) and up to 0.6 percentage points for PM<sub>2.5</sub> (TL35).

All options considered deliver economic benefits for society as a whole as well as for transport operator and consumers representing a classical win-win situation.

Benefits for society are expressed as the additional net savings that could be achieved compared to the corresponding baseline. These savings are calculated as the difference between the fuel savings and the capital costs over the lifetime of the vehicles. The analysis, using two sets of cost curves (base and high costs) demonstrated that, both in 2025 and in 2030, very significant cumulative net savings can be realised under all options. The significant fuel savings strongly outweigh the additional capital costs. These high savings reflect that HDVs have an average lifetime mileage of around 1.2 million km, which is about six times higher than cars. Such a mileage leads to total fuel costs of about 400,000 EUR over the lifetime of a vehicle.

The maximum CO<sub>2</sub> reduction trajectories with respect to net economic benefits including the avoided cost of CO<sub>2</sub> from a societal perspective are TL30, TL32 and TL35 not taking into account the higher uncertainty that comes with the highest target levels. When considering the base cost curves, the estimated net economic benefits per lorry are

32,193 to 52,369 EUR in 2025 and 77,360 to 87,278 EUR in 2030. Basing the analysis on the high cost curves, net savings per lorry range from 34,814 to 41,881 EUR in 2025 and from 59,060 to 76,963 EUR in 2030.

From the perspective of the transport operator, the 'total cost of ownership' reflects the change in costs from an end-use perspective for an 'average new lorry'. The analysis shows significant cumulative net savings for transport operators, the majority of whom are SMEs. They are smaller than the societal benefits, and the difference is mainly stemming from the fact that the transport operator will not take the avoided CO<sub>2</sub> costs into account.

During the first use (5 years) of the vehicle and when using the base costs curves, a transport operator could realise cumulative net savings per lorry of 7,323 to 37,589 EUR in 2025 and 30,339 to 72,120 EUR in 2030 for the range of options considered. This is equivalent to saving 1-4 % of its operating costs in 2025 and 3-12 % in 2030.

The analysis of the two sets of cost curves demonstrated that as the fleet-wide CO<sub>2</sub> target levels get tighter, the capital costs as well as the fuel cost savings increase. Yet, the increase in fuel cost savings is higher than that in capital costs leading to increasing overall net savings. This trend is observed both from a first use as well as from a second use perspective.

However, consideration is needed of the lead time to implement the new technologies, as well as their impacts on the manufacturing costs. As for all energy efficiency investments, an upfront investment is required for deploying CO<sub>2</sub> saving technologies for HDVs.

Additional manufacturing costs for a 2025 lorry under the options TL20 to TL35 increase from 858 to 7,339 EUR under the base cost assumption and from 3,077 to 27,797 EUR under the high cost assumption. In relative terms, this represents between 0.8% and 6.7% and between 2.8% and 25.3%, of the purchase price of the vehicle, for the base cost and high cost assumptions, respectively.

Higher manufacturing costs for 2030 reflect the existing uncertainties over the costs and availability of new technologies in that time frame. The introduction of the regulatory standards might, however, affect the development and uptake of technologies, and thus their availability and costs in a 2030 perspective. Actual developments in technology costs will be reviewed as foreseen in 2022.

All options are expected to reduce slightly the energy demand with the biggest reductions observed under options TL30, TL 32 and TL35.

Under the different target options, the decrease in the fuel costs leads to a decrease in freight costs, and consequently an increase in freight transport activity. However, for all the options assessed, this increase remains limited in the range of 0.2% to 0.4% in 2025 and 0.5% to 0.9% in 2030 depending on the target level option.

Furthermore, the different policy options have a limited impact on the reduction of the total costs of freight (HDV) transport per activity, by less than 1% in 2025 and in the order of 1% to 3% in 2030 depending on the target level.

As regards the macro-economic impacts, the results show an almost negligible positive impact compared to the baseline in terms of EU-28 GDP for the all options considered. The sectors mostly affected are the ones associated to petroleum products showing a gradual decrease in turnover as CO<sub>2</sub> targets become stricter and the manufacturing of

motor vehicles sector, while the transport service sector is expected to be positively affected by the introduction of CO<sub>2</sub> targets.

The targets are also expected to have a small but positive impact on employment, in particular in the sectors of transport and construction. The latter is driven by higher activity in the construction sector as transport services become cheaper.

In light of the analysis carried out, on one hand, options TL30, TL32 and TL35 score better than option TL20 on effectiveness in reducing CO<sub>2</sub> emissions as well in terms of net savings from a societal, first use and second use perspective. Those options score also better in terms of incentives for innovation. On the other hand, in particular options TL32 and TL35, with the strictest target levels, score less positively on proportionality as they lead to high manufacturing costs, especially in 2030.

In terms of coherence, a key consideration is related to the way HDV CO<sub>2</sub> targets would deliver a cost-effective contribution to reducing emissions of the sectors covered by the Effort Sharing Regulation by 2030.

Chapter 6 shows a significant difference between the emission reduction in road transport in the *EUCO30* scenario as compared to the baseline. With the proposal for cars and vans, this difference gets significantly smaller, from around 8 to 4 percentage points.

This gap could be progressively closed with the implementation of CO<sub>2</sub> standards for lorries. Option TL20 would reduce the gap by about 25%, while option TL35 would halve the gap.

In this respect, stricter HDV targets enable Member States in meeting their target under the Effort Sharing Regulation taking into account also that depending on the Member State other sectors covered by that Regulation might have a lower than average cost-effective emission reduction potential. However, the strictest target scores less positively against the coherence criteria in view of the increased manufacturing costs.

The options considered covered the range of views expressed by stakeholders, with HDV manufacturers supporting a target level close to the baseline, while environmental NGOs are in favour of the most ambitious target levels considered as part of these options.

### *7.1.5 Timing*

The three options on timing mainly differ in their effectiveness and efficiency.

Setting a CO<sub>2</sub> target for 2025, as under options 1 and 2, would provide a clear and early signal for the HDV sector to increase the availability of more fuel-efficient vehicles in the EU from the early 2020s on. Such a target can be achieved with readily available technologies which are currently not widely deployed in the market. It would address the market uncertainties and the inertia in the HDV market in deploying such technologies. It would also incentivize the European automotive sector to swiftly upscale their investments in key fuel-saving technologies and benefit early on from the economies of scale and learning in the context an increasing competitive market.

At the same time, a 2025 target would leave sufficient flexibility to manufacturers to phase in more efficient technologies and hence give sufficient lead time for the automotive supply chain to adapt.

It is in particular effective in achieving the first specific objective by reducing CO<sub>2</sub> emissions early. As a result, cumulative emission reductions over the period up to 2030 would be higher. It is also most effective against the second and third specific objective

as transport operators or consumers depending on pass through would accrue significant fuel savings or transport cost savings in the period up to 2030, while technological deployment and innovation would be stimulated early on. This would also increase the efficiency of the policy.

A binding 2025 target is also coherent with the broader climate and energy policy by ensuring that the HDV policy will contribute to Member States delivering on time on their national annual emission reduction targets set under the Effort Sharing Regulation up to 2030.

In contrast, delaying the first CO<sub>2</sub> target for HDVs until 2030 as under option 3 would cause the uptake of existing available fuel-efficient technologies to be postponed, leading to higher emissions and lagging technology deployment and innovation as a result of the inertia and uncertainties in the HDV market. Transport operators and consumers would also miss out on fuel savings.

Combining a binding 2030 target with a 2025 target as under option 2 would in principle score high in terms of effectiveness as this would send a clear signal towards the HDV sector to continue deploying more fuel-efficient technologies over the next 15 years.

However, as explained in Chapter 6, given the current lack of robust information on how technology performance and costs might evolve in the medium term as regards the more innovative and prospective technologies, there is a risk that a binding 2030 target could not be set at the most cost-effective level right now. It will therefore be necessary to review the 2030 CO<sub>2</sub> emission targets in 2022 once sufficient certified CO<sub>2</sub> emission data have been collected and more information is available on the costs and savings of the prospective technologies, reducing the level of uncertainty on these technologies.

In view of the above, option 1 and 2 score best on effectiveness and efficiency as it provides for early emission reduction, fuel savings, incentives for technology deployment and innovation as well as signals the need for continued action after 2025. For both options, it will be essential to provide for a review of the initially established 2030 target to ensure its robustness in view of the certified data which will be gathered from 2019 on under the reporting and monitoring legislation.

A strong majority of stakeholders preferred fixed dates combined with an early review clause over annual reduction targets, justifying their preference by referring to the need for planning certainty and the necessary lead time for industry to develop the technology. Industry favours option 2 and environmental NGOs option 1.

## **7.2 Distribution of EU-wide HDV fleet CO<sub>2</sub> emission target level across vehicle groups and manufacturers**

The way the EU fleet-wide CO<sub>2</sub> emission reduction target is distributed across vehicle (sub-) groups and manufacturers should first and foremost not affect the overall effectiveness of the policy. It would neither have an effect on the overall level of innovation in the HDV sector. Therefore, the two options considered ensure the same level of effectiveness and coherence.

However, they differ slightly in terms of efficiency. Although option 1 in principle takes into account the specificities of the different vehicle sub-groups and minimises the total costs across all HDVs, it does not provide manufacturers with flexibility in finding a cost-optimal way to achieve their specific CO<sub>2</sub> emission reduction targets. This is particularly relevant in case of year to year fluctuations and changes in the composition



of their future fleet sold and the sequence of the development and gradual roll-out of new technical developments.

Option 2 provides for such flexibility by allowing for the possibility of balancing an underperformance of vehicles in certain sub-groups with an overachievement of the targets for other vehicle sub-groups. Therefore, option 2 scores better in terms of efficiency and proportionality than option 1. Also, HDV manufacturers expressed their support for option 2.

### **7.3 Incentive for Zero- and Low-Emission Vehicles (ZEV/LEV)**

When comparing the four options and one variant regarding the type and level of incentive, special consideration needs to be given to the fact that ZEV/LEV lorries are mostly in prototype phase and have not reached the stage of commercial deployment.

In view of this, as long as the incentive mechanism contains sufficient safeguards preventing a weakening of the CO<sub>2</sub> targets, the scope option covering both ZEV and LEV for the purpose of the incentive scores higher in terms of effectiveness, efficiency, coherence and added value than the more restrictive option of allowing such incentives only for ZEVs.

As regards the type of incentive, a binding mandate or a two-way crediting system could in principle provide the strongest regulatory signal for industry to invest in ZEV/LEV.

However, taking into account the very low penetration of ZEV/LEV in the HDV fleet and the scarcity of robust data on such vehicles, defining an appropriate level for a binding ZEV/LEV mandate or a benchmark until 2030 on the basis of high uncertainties is quite challenging. There is a significant risk that the level chosen would be either too demanding - thus undermining the efficiency of the incentive - or too weak - which would limit the effectiveness of the incentive, while putting at risk the environmental effectiveness of the entire policy.

Therefore, a binding mandate and a one- or two-way crediting system based on a pre-defined benchmark are likely not to be efficient and score lower on proportionality than a super-credit system, which does not require setting mandates or benchmarks.

If the uptake of ZEV/LEV is higher than expected, super-credits or a one-way crediting system could undermine the environmental integrity of the policy by weakening of the overall CO<sub>2</sub> target. However, this risk can be minimised by setting a cap for a maximum possible increase of emissions.

These two options of a ZEV/LEV incentive would provide manufacturers with greater flexibility in composing their fleet, in particular in view of the current early stage of development of the market for ZEV/LEV.

As regards the scope for a possible incentive mechanism, the definition of ZEV/LEV would need to be set to cover vehicles with CO<sub>2</sub> emissions significantly below the fleet-wide average emissions in order to preserve the environmental integrity of the system and incentivize innovation towards zero emission mobility. Furthermore, LEV with the lowest emissions should be incentivized more.

The effectiveness and added value of the ZEV/LEV incentive mechanism could be increased if it were to cover zero-emission buses and smaller lorries, which would not be subject to the CO<sub>2</sub> targets until the review of the legislation.

In those HDV segments, the commercial deployment of ZEV has already started. Although the uptake of such vehicles would already be incentivised under the proposed revision of the Clean Vehicle Directive<sup>65</sup>, a complementary incentive could further speed up the market uptake of these technologies, which could in turn promote and accelerate the dissemination in other HDV segments. This is in particular true for smaller lorries and, to a lesser extent, for buses which are likely to benefit more from public procurement policies.

Bringing zero-emission buses and smaller lorries under the ZEV/LEV incentive mechanism would, however, reduce the need to lower the emissions from the largest HDVs covered by the standards. Their contribution to the incentive scheme should therefore be restricted so that ZEV/LEV for the largest vehicles remain sufficiently incentivized. Furthermore, there is a risk of creating a competitive distortion (i) among lorry manufacturers, as one of them does not manufacture buses and manufacturers have different shares of buses in their portfolio (ii) for manufacturers producing buses only, as those would not receive such incentives as compared to operators of large HDVs.

HDV manufacturers expressed their support for the introduction of an incentive scheme in the form of super credits (option 1), while environmental NGOs were in favour of introducing a mandate (option 4).

## **7.4 Elements for Cost-Effective Implementation (Flexibilities)**

### *7.4.1 Exemptions*

The option of exempting vocational vehicles from meeting the CO<sub>2</sub> emission targets would slightly reduce the effectiveness of the policy in reducing emissions from HDVs. However, due to the small number of vocational vehicles and their significantly lower mileage, the effect on total emissions is not deemed to be substantial. The additional administrative burden to capture these vehicles adequately would be high because of the large variety of vocational vehicles.

The exemption might reduce the coherence of the policy and create a risk of market distortions because it leads to a different treatment of genuinely similar vehicles, which are used for very different purposes. However, these risks are limited since these vocational vehicles will be clearly identified through the necessary changes in type approval legislation by the time when the standards will apply.

This option is also cost-efficient and proportional in view of the specific technical characteristics of the targeted vehicles.

HDV manufacturers supported the introduction of exemptions.

### *7.4.2 Flexibilities across manufacturers*

#### *7.4.2.1 Pooling*

As explained in Chapter 6, pooling in itself should not negatively affect the achievement of the EU fleet-wide CO<sub>2</sub> emission reduction target. Consequently, this option does not affect the effectiveness of the policy.

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<sup>65</sup> SWD(2017) 366 final

However, pooling allows manufacturers to reach the CO<sub>2</sub> emission targets at a lower cost and thus could increase the efficiency of the policy.

In spite of that, due to the specificities of the HDV sector, this option is not optimal in term of coherence and proportionality. Pooling poses the risk of limiting competition between the very limited number of individual manufacturers operating in an already concentrated oligopolistic market. Pooling could lead to a narrow range of technological options available on the market and slow down competition and innovation.

The majority of stakeholders across all stakeholder groups was in favour of pooling, to support the cost-effective implementation of the targets. However, civil society organisations supported trading only and HDV manufacturers considered the introduction of pooling not to be necessary.

#### *7.4.2.2 Trading*

Trading can reduce overall compliance costs for manufacturers by providing for additional flexibility in meeting the targets. Consequently, as with pooling, trading could positively affect the efficiency of the policy, but would have little if any effect on its effectiveness.

The efficiency gains will depend on the level of liquidity in the market. Given the small number of manufacturers, it is uncertain whether the necessary level of liquidity for trading to become efficient would be achieved. As in the case of pooling, trading has a risk of negative effects on competition due to the limited number of market participants.

The majority of stakeholders across all stakeholder groups was in favour of trading to support the cost-effective implementation of the targets. HDV manufacturers consider the introduction of trading not to be necessary.

#### *7.4.3 Flexibilities across different target years*

Performing an annual compliance check against the applicable targets ensures that those targets are effectively met each year. This increases the effectiveness of the policy and its coherence with the overarching EU objectives.

However, having fixed annual targets (option 1) also limits the flexibility for HDV manufacturers to deal with unforeseen fluctuations in their fleet composition, e.g. due to varying customer preferences or other external factors like economic growth, or with the existing differences in manufacturer-specific innovation cycles.

Allowing banking and borrowing (option 2) would help to overcome this and thus to reduce compliance costs and to improve the efficiency of the policy. Furthermore, this option would provide for rewarding early action including before the first year of application of the new targets.

Care should be taken in the design of banking and borrowing in order to prevent negative impacts on environmental effectiveness. This could occur if potential technological progress were to be grossly underestimated and banking would allow for an extensive accumulation and carry over of large amounts of credits. Borrowing could lead to a situation where manufacturers would not be able to balance borrowed credits, or in situations where manufacturers in debt would go out of the market. Therefore, as described in Chapters 5 and 6, the option for banking and borrowing foresees a number of mitigating measures, which should ensure that the environmental objective is met.

Banking and borrowing could improve competition between manufacturers.

The majority of stakeholders across all groups was in favour of banking/borrowing to support the cost-effective implementation of the targets. However, civil society organisations argued that this may undermine the effectiveness of the legislation.

## **7.5 Governance**

### *7.5.1 Real-world emissions*

Options 1 and 2, both involving the collection, publication and monitoring of real-world fuel consumption data score positively against all assessment criteria. They will ensure the availability of more representative certified CO<sub>2</sub> emission data, which will stimulate technological innovation, facilitate reducing CO<sub>2</sub> emissions and the actual fuel-cost savings. These options would thus increase the effectiveness, coherence and added value of the regulatory framework.

The availability of real-world fuel consumption data would allow the verification of the assumptions made on the gap between the CO<sub>2</sub> values obtained from VECTO and the average real-world emissions. This would in turn make it possible to take corrective actions in case significant divergences would be found so as to ensure the overall integrity and robustness of the regulatory framework. In addition, the publication of real-world fuel consumption data would strongly improve transparency for consumers and may influence purchase decisions towards more efficient HDVs.

The only difference between the second and the third option is the nature of the monitoring devices used to collect the real-world fuel consumption data. Using the currently installed non-standardised fuel consumption measurement devices could result in non-comparable data, which risks rendering this option ineffective having little added value.

In comparison, the use of standardised measurement devices would create a more robust framework ensuring data quality and comparability, thus reinforcing the importance of the reporting obligation. Therefore, option 2 scores best in terms of effectiveness, coherence and added value. The slightly higher costs of introducing standardised measurement devices could be offset by the expected benefits.

A clear majority of stakeholders across different groups viewed it important to develop processes for assessing the certified CO<sub>2</sub> emissions against real driving emissions. Only some automotive component suppliers and vehicle manufacturers were either neutral or explicitly against.

### *7.5.2 Market surveillance*

The option introducing an obligation to report deviations found during market surveillance and the introduction of a correction mechanism scores positively in terms of effectiveness, efficiency and added value.

This obligation would complement the reporting of real world CO<sub>2</sub> data by ensuring that CO<sub>2</sub> emissions of vehicles, as type-approved are correct or that these are swiftly corrected in case of deviations. Since type-approved CO<sub>2</sub> emission values are used for assessing CO<sub>2</sub> target compliance introducing such a verification and correction procedure is critical to ensure that the CO<sub>2</sub> emission reduction objective will actually be achieved.

During the public consultation, most automotive component suppliers and vehicle manufacturers were against or neutral on the introduction of an ex-post feedback mechanism requiring compliance of the certified CO<sub>2</sub> emissions with real-driving

emissions. Such an ex-post feedback mechanism was supported by logistics operators, vehicle fleet operators, and civil society organisations.

### 7.5.3 Penalties

When penalties are set at an optimal level, these will have a deterrent effect and steer market players towards a preferred course of action. Thus, effective financial penalties will ensure that manufacturers comply with the CO<sub>2</sub> emission targets. The absence of effective financial penalties, poses the risk of manufacturers paying the fine, while deliberately not complying with the CO<sub>2</sub> emission targets, thus undermining the effectiveness of the policy.

Consequently, financial penalties would enhance the effectiveness, coherence and efficiency of the policy and, when set at an optimal level, ensure its proportionality.

## 8 PREFERRED OPTION

While for most of the issues a preferred option has been identified, this is not the case for the following issues, for which trade-offs between the various options are described in Section 7 and Annex 3.2 with a view of informing the decision making process:

- the level and timing of the CO<sub>2</sub> emission targets
- the specific design elements of the incentive system for zero and low emission vehicles.

**Table 7: Overview of the preferred options**

<b>Preferred Options</b>	
<b>1. Emission target</b>	
Scope	Cover groups 4, 5, 9 and 10 using whole-vehicle CO <sub>2</sub> standards
Metric	Tank-to-wheel approach
Metric unit	g CO <sub>2</sub> /tkm
CO <sub>2</sub> target levels	See Section 7 and Annex 3.2 for a summary of the costs, benefits and associated uncertainties of a range of options.
Timing	Binding CO <sub>2</sub> target from 2025 and a new target in 2030. As regards the legal nature of the 2030 target (binding/aspirational), it is less relevant as it will be subject to a review in 2022, when more robust information on emissions as well as performance and costs of new technologies will be available. The review would also extend the scope to cover smaller lorries and buses following the necessary further development of VECTO and the extension of the certification legislation.
<b>2. Distribution of EU fleet-wide CO<sub>2</sub> emission target level</b>	
	A single target for each manufacturer, calculated as the weighted average of the HDV sub-group targets, based on the same relative reduction for each sub-group
<b>3. ZEV/LEV incentives</b>	

	Super-credits with sufficient safeguards preventing a weakening of the CO <sub>2</sub> targets
<b>4. Elements for cost-effective implementation</b>	
Exemptions	Exempt vocational vehicles
Flexibilities across manufacturers	Do nothing
Flexibilities across different target years	Banking and borrowing including the rewarding of early action within certain limits aimed to safeguard the environmental effectiveness
<b>5. Governance</b>	
Real-world emissions	To mandate collection, publication and monitoring of real-world fuel consumption data reported by manufacturers using standardised measurement devices.
Market surveillance	To set a mandate for the Commission for defining in-service conformity tests including such done by independent third parties through a delegated act. Deviations found during such in-service conformity to be reported to the Commission and a subsequent correction of the monitoring data to be applied.
Penalties	To introduce financial penalties for non-compliance with the CO <sub>2</sub> emission reduction targets.

### **REFIT (simplification and improve efficiency)**

The initiative in itself would not entail any additional administrative costs for type-approval authorities. The costs related to certification and the monitoring and reporting of data on CO<sub>2</sub> emissions have been considered in the context of those proposals.

## **9 HOW WOULD IMPACTS BE MONITORED AND EVALUATED?**

The actual impacts of the legislation will be monitored and evaluated against a set of indicators tailored to the specific policy objectives to be achieved with the legislation. A mid-term review of the legislation foreseen in 2022 would allow the Commission to assess the effectiveness of the legislation and, where appropriate, propose changes.

Under the proposed HDV Monitoring and Reporting Regulation<sup>66</sup>, the Commission will collect the CO<sub>2</sub> emissions and fuel consumption data resulting from the certification procedure. Efficient monitoring is conditional on a well-functioning certification process and reliable emission data from VECTO. The European Environment Agency (EEA) will combine the registration data from national authorities with the monitoring data from manufacturers and publish per manufacturer and vehicle group annual monitoring data for each certified new vehicle registered in the EU.

Moreover, this Impact Assessment puts forward the option of complementing the proposed Regulation on monitoring and reporting of CO<sub>2</sub> emissions data from HDV with two additional monitoring measures.

<sup>66</sup> COM(2017) 0279 final

The first one is the collection, publication, and monitoring of real world fuel consumption data reported by manufacturers based on mandatory standardised devices.

The second one introduces in-service conformity tests and the obligation to report deviations from type approval values, which could be tackled by a correction mechanism.

These two measures would reinforce the monitoring process and ensure the effectiveness of the proposed legislative initiative. They entail a limited additional administrative burden on type approval authorities. In light of the importance of ensuring transparency and the representativeness of monitored CO<sub>2</sub> emission values, this appears well justified.

## 9.1 Indicators

For the specific policy objectives the following core monitoring indicators have been identified:

- **Reduce CO<sub>2</sub> emissions from the HDV sector** in line with the requirements of EU climate policy and the Paris Agreement
  - The EU-wide fleet average of the CO<sub>2</sub> emissions measured at type approval will be monitored annually on the basis of the monitoring data so that it can be compared against the target level set in the legislation.
  - Total HDV GHG emissions will be monitored through Member States' annual GHG emissions inventories.
  - The deployment of fuel-efficient technologies, their costs and the resulting fuel savings will be monitored on the basis of data collected from manufacturers, suppliers and experts. Information will also be available through the proposed Regulation on monitoring and reporting of CO<sub>2</sub> emissions data from HDVs.
- Facilitate a **reduction in operating costs for transport operators**, most of which are SMEs, and more broadly of transportation costs for consumers depending on pass-through of fuel savings:
  - The development in fuel cost savings will be monitored through the evolution of the EU-wide fleet average emissions for the various type of vehicle groups. This monitoring will also take account of the collection of real world fuel consumption data and in-service conformity checks, if available.
  - The development of freight costs will be monitored on the basis of data to be collected from transport operators, customers and experts.
- Maintain the **technological and innovative leadership** position of EU HDV manufacturers and component suppliers
  - The level of innovation will be measured in terms of new patents by European HDV manufacturers related to fuel-efficient technologies and zero/low-emission vehicles, including through publicly available patents databases. Data will be compared against main competitors from other world regions.
- **Employment:** The level of employment will be monitored on the basis of publicly available Eurostat statistics on sectoral employment data for the EU.

- **Air quality:** The ambient levels of air pollutants such as NO<sub>x</sub> and PM<sub>2.5</sub> will be monitored by the Commission in application of the air quality legislation and reported by the EEA under AirBase.<sup>67</sup>
- **Energy security:** Improvements in energy security will be monitored on the basis of Eurostat statistics on fuels imports, including transport fuels.

The methodology for evaluating the legislation will put particular emphasis on ensuring that causality between the observed outcomes based on the above indicators and the legislation can be established. In this context, methodological elements will include the establishment of a robust baseline/counterfactual scenario and the use of econometric analysis of empirical data.

## 9.2 Operational objectives

Operational objectives	Indicators
Reach a specific CO <sub>2</sub> emissions target level by the target year(s)	Compliance of manufacturers with their specific emissions target in the target year(s)
Stimulate the deployment of ZEV/LEV in a specific period	Share of ZEV/LEV in that period
Achieve actual CO <sub>2</sub> emissions reductions maintaining a minimum "emissions gap"	Divergence between real-world emissions and certified/reported CO <sub>2</sub> emissions data Deviation between in-service conformity results and certified/reported CO <sub>2</sub> emissions data
Lower operating costs for transport operators	Evolution of the EU-wide fleet average emissions for the various types of vehicle groups, as well as real world fuel consumption data.
Increase technological innovation	Number of new patents registered by European HDV manufacturers related to fuel-efficient technologies and zero/low-emission vehicles

<sup>67</sup> AirBase is the European air quality database maintained by the EEA through its European topic center on Air pollution and Climate Change mitigation. It contains air quality monitoring data and information submitted by participating countries throughout Europe. The air quality database consists of a multi-annual time series of air quality measurement data and statistics for a number of air pollutants.





Brussels, 17.5.2018  
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PART 2/2

**COMMISSION STAFF WORKING DOCUMENT**

**IMPACT ASSESSMENT**

*Accompanying the document*

**Proposal for a Regulation of the European Parliament and of the Council  
setting CO<sub>2</sub> emission performance standards for new heavy duty vehicles**

{COM(2018) 284 final} - {SEC(2018) 233 final} - {SWD(2018) 186 final}

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# 1 ANNEX 1: PROCEDURAL INFORMATION CONCERNING THE PROCESS TO PREPARE THE IMPACT ASSESSMENT REPORT AND THE RELATED INITIATIVE

## 1.1 Organisation and timing

The Directorate-General for Climate Action is the lead service for the preparation of the initiative (PLAN/2017/1474) and the work on the impact assessment.

An inter-service steering group (ISG), chaired by the Secretariat-General, was set up in December 2017 with the participation of the following Commission Directorates-General: Legal Service; Economic and Financial Affairs; Internal Market, Industry, Entrepreneurship and SMEs; Environment; Mobility and Transport; Joint Research Centre; Taxation and Customs Union; Justice and Consumers, Employment, Social Affairs and Inclusion, Research and Innovation, Competition, Energy, Communications Networks, Content & Technology.

The ISG met three times between December 2017 and the end of February 2018, to discuss the draft impact assessment.

## 1.2 Consultation of the Regulatory Scrutiny Board (RSB)

The Regulatory Scrutiny Board received the draft version of the present impact assessment report on 28 February 2018 and following the Board meeting on 28 March 2018 issued a negative opinion on 4 April 2018.

The Board made the following recommendations, which were addressed in the revised draft impact assessment report as indicated below.

<u>Main RSB considerations</u>	<u>Response</u>
<p>The Board acknowledges efforts to quantify impacts of the policy options, and takes note of planned clarifications to the draft report.</p> <p>However, the Board gives a negative opinion, because the report contains important shortcomings that need to be addressed particularly with respect to the following key aspects:</p>	
<p>(1) The options seek to correct market failures that allegedly lead HDV producers to underinvest in fuel efficiency and emissions reduction. The report does not convincingly establish the scale and relevance of such market failures.</p>	<p>The description of the barriers hindering the uptake of more fuel-efficient technologies and their relevance, as presented in section 2.2.2 of the report, has been revised, clarified and expanded.</p> <p>The different causes have been described in section 2.2.2. The first key issue is that market players do not take into account environmental benefits for society to the extent they do not enter their profit calculations as costs and benefits are not</p>

directly priced into the market.

Next to this, there is imperfect and information asymmetry. Sellers know better than buyers the potential of fuel-saving technologies. Buyers of lorries find it difficult differentiating fuel savings resulting from individual technologies. Furthermore, the net savings of those individual technologies will be perceived as rather modest, as most of them do not save more than about 0.5% of the total operating costs. If transport operators want to reap the full benefits, they will have to select a number of technologies at the same time, which makes the purchasing decision more complex. As a result, the market penetration of such readily available technologies is limited, despite their considerable net savings over time.

The availability of VECTO data from 2019 will help addressing asymmetries but is unlikely to be sufficient to close them as the access to this technical informal will not be automatic and will remain complex for transport operators which are mainly SMEs. This is confirmed by the experience in the US.

The barrier on asymmetry of information also results in an 'adverse selection' problem.

These issues are enhanced by the concentrated market situation on the side of the manufacturers, which contributes to low competitive pressure.

Furthermore, the market providing transport services is very competitive, and it is likely that a part of the fuels savings is passed through via a reduction of freight cost to the final customer of transport services. Because of that, transport operators will be uncertain to what extent purchasing a highly fuel efficient truck will translate into a higher income for them.

The US experience shows that despite convincing evidence of underinvestment in fuel-efficient technologies, empirical evidence for its drivers is more difficult to

	establish.
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<p>(2) The report downplays uncertainties about capabilities and costs of technologies to increase fuel efficiency. It does not assess how these uncertainties affect the choice of fuel efficiency targets, or whether these targets should be voluntary or mandatory.</p>	<p>On these points, the report has been revised and the analysis expanded in several places.</p> <p>The newly-added Table 1 provides an overview of technologies for reducing CO<sub>2</sub> emissions, grouping them into five categories according to their current and future market penetration, and constraints for their widespread deployment.</p> <p>As illustrated in the newly-added Table 2 and Figure 4, the first key finding is that a series of cost-effective technologies are readily available, but still have a limited market penetration, despite their low costs and the high net savings they deliver. Other technologies will become soon readily available. Together, these technologies would yield emission reductions of up to 15-20% within the 2025 time frame.</p> <p>On the other hand, the time frame for the widespread market penetration of more prospective technologies and alternative powertrains, which are less mature, as well as their cost saving potential, is more uncertain.</p> <p>Section 7 has also been expended to provide more information on the associated uncertainties on a range of options.</p> <p>Furthermore, the revised Sections 5.1.5, 6.2.5 and 7 discuss the pros and cons of making a target for 2030 mandatory as opposed to aspirational.</p> <p>The option of setting only voluntary or aspirational targets is reflected in the baseline option for the target levels, as experience with a voluntary approach in the light-duty vehicles sector has proven that this does not result in higher emission reductions than what could be expected as a result of “autonomous improvements”.</p>
<p><b><u>Further RSB considerations and adjustment requirements</u></b></p>	<p><b><u>Response</u></b></p>
<p>(1) The report should more clearly present the Commission’s proposed strategy to reduce CO<sub>2</sub> emissions from Heavy Duty Vehicles by 2030. The overview should explain why and how the initiative’s scope</p>	<p>The Commission’s past and future work on measures to reduce CO<sub>2</sub> emissions from Heavy Duty Vehicles by 2030 is further explained in Section 1.4 of the report.</p> <p>The initiatives for extending the scope have</p>

<p>may evolve. It should explain the sequence of various measures, including external ones that would allow an extension of the scope. It should clarify the purposes of the mid-term review.</p>	<p>been further elaborated in Section 5.1.1.</p> <p>This work is further detailed in the dedicated Annex 8.</p> <p>The purposes of the mid-term review are threefold:</p> <ul style="list-style-type: none"> <li>• establish or confirm the 2030 targets for the vehicle groups covered by the first phase of the CO<sub>2</sub> standards;</li> <li>• extend the scope to other groups of HDVs, taking account of the updates of VECTO and the Certification Regulation;</li> <li>• review the modalities for implementation.</li> </ul> <p>This is further detailed in Section 5.1.5</p>
<p>(2) The problem definition section should do more to establish that HDV owners currently underinvest in fuel-saving technologies. The report's current explanations for this market failure are not convincing in view of the report's assumptions on the market structure in trucking and vehicle manufacturing. The behaviour of market participants rather seems to suggest doubts about how effectively technological innovations will deliver fuel savings and at what cost, and thus provide a sufficient return on additional investments in technology. Evidence to support this latter explanation comes from the stakeholder consultations and the backing of the VECTO system presented in annexes.</p>	<p>Section 2 of the report has been thoroughly revised on this point, after revisiting existing literature and considering in particular the US experience in this area. This includes the newly added Table 2.</p> <p>The text now indicates which are the main causes for the underinvestment. Also, the role of information asymmetries resulting in underinvestment has been further highlighted.</p> <p>US experience confirms that there is ample evidence of underinvestment, but the empirical evidence for its drivers is more difficult to establish.</p>
<p>(3) The report should spell out uncertainties surrounding the basic parameters of the initiative. It should consider these uncertainties when analysing the large net savings gains and comparing options. Doing so would clarify potential risks surrounding the political choice of setting target HDV CO<sub>2</sub> emission reductions. Similarly, the report should discuss the pros and cons of making a target for 2030 mandatory as opposed to aspirational.</p>	<p>The newly-added Table 1 provides an overview of technologies for reducing CO<sub>2</sub> emissions, grouped according to their current and future market penetration, and constraints for their widespread deployment.</p> <p>Based on this analysis, the report distinguishes two main categories of technologies.</p> <p>On the one hand, there is a series of readily available technologies, for which the emission reduction performance and costs are well established and which can deliver</p>



	<p>CO<sub>2</sub> savings up to 20% in the short term.</p> <p>Other technologies are less mature and their widespread deployment less certain. Uncertainties are higher with regards to these technologies.</p> <p>The link between these technologies and the target levels and impacts is described in Sections 5.1.4 and 6.2.4, respectively.</p> <p>Section 7 and Annex 3.2 provides for a summary of the costs, benefits and associated uncertainties of the range of options considered. Text has been added to sections 5.1.5, 6.2.5 and 7, discussing the pros and cons of making a target for 2030 mandatory as opposed to aspirational.</p>
<p>(4) The report should better reflect the positions of all different stakeholder groups. This applies especially to the position of HDV manufacturers, who would seem to prefer an overall approach to emission reduction that does not impose emission reduction standards. These manufacturers may not agree with the initiative's expectations about the costs and benefits of the technological advances. The report should clarify how the initiative takes their concerns into consideration.</p>	<p>In addition to the overview in Annex 2, information about stakeholders' views has been added, e.g. in Sections 2.1.3, 2.4, 3.3, 5.1.4, 5.2 and 5.4.3.</p> <p>In Section 6.1, it has been clarified how the use of the "high" cost curves relates to the concerns expressed by stakeholders from the automotive manufacturing sector, reflecting the uncertainties over the costs and availability of new technologies for 2030.</p>
<p>(5) The initiative aims to preserve the competitiveness of the EU HDV manufacturers, but the report does not explain how effective the options would be in achieving this objective.</p>	<p>As clarified in Section 2.1.3 of the report, the focus of the third problem identified is on the risk for EU manufacturers to lag behind in terms of innovation in new technologies and hence to lose global technological leadership.</p> <p>In Section 6, this aspect has been considered where relevant and a new Section 6.2.4.2.7 has been added to illustrate the impact of the target level options on innovation and technological leadership. Section 7 has also been further elaborated on this point.</p>

The Board received a revised draft version of the present impact assessment report on 11 April 2018 and issued a positive opinion on 19 April 2018.

The Board made the following recommendations, which were addressed in the revised impact assessment report as indicated below.

<b><u>Main RSB considerations</u></b>	<b><u>Response</u></b>
<p>The Board acknowledges the clarifications to the draft report, in particular on market information asymmetries and uncertainties related to technical progress.</p> <p>The Board gives a positive opinion, with a recommendation to further improve the report with respect to the following key aspect:</p>	
<p>The report could better explain what causes inertia of the trucking industry in developing new fuel saving technologies and how market uncertainties lead transport operators to underinvest in these technologies.</p>	<p>The revised report contains an additional box in section 2.2.2 related to the drivers for inertia in the HDV sector. The box provides more specific information and explains more clearly the causes of such inertia.</p> <p>This concerns firstly the structure of the market where sellers offer packages of additional technologies generally as 'premium' options and not as standard technologies. It is a profitable strategy that allows sellers to charge more to "premium customers". As such, market forces are not likely to incentivise manufacturers to promote technologies: their products would may not be bought by buyers with a short-term cost awareness, and also the margins they make on premium buyers would shrink. Furthermore, the absence of a regulatory framework creates uncertainties for the required investments from manufacturers in new technologies.</p> <p>This situation is likely to persist in the existing concentrated market structure. The market is indeed very concentrated on the side of the HDV manufacturers, which contributes to low competitive pressure. In contrast, the majority of freight operators are small businesses working on tight margins.</p> <p>The box also clarifies that a second driver is the presence of market uncertainties.</p>

	<p>Transport operators have difficulties with assessing fuel savings resulting from technology adoption. Other considerations are the widespread perception of transport operators that operational measures such as driver training are sufficient to reduce fuel consumption and that the first user might not be able to charge a premium when selling second-hand.</p> <p>Section 7 has also been revised to consider the effectiveness of the various options, regarding the target levels and the timing, in addressing the market uncertainties and inertia in the HDV market.</p>
<p><b><u>Further considerations and recommendations for improvement</u></b></p>	<p><b><u>Response</u></b></p>
<p>(1) The revised report better presents the Commission's strategy to reduce CO<sub>2</sub> emissions from HDVs by 2030. Information about this could usefully be consolidated and presented upfront. The report could better highlight the importance of earlier work, e.g. on measuring, certification, monitoring and reporting, for regulating CO<sub>2</sub> emissions in the HDV sector.</p>	<p>The revised report adds and explains upfront, in section 1.4, the 2014 Commission's Strategy for reducing HDVs fuel consumption and CO<sub>2</sub> emissions. The Strategy provided the basis for the action taken to address CO<sub>2</sub> emissions from this sector.</p> <p>The section also presents more clearly the work carried out as a follow-up to the Strategy in the form of the development of VECTO simulation tool, the adoption of the Certification Regulation and the preparation of the Monitoring and Reporting Regulations.</p> <p>The revised section also underlines the importance of this earlier work which is a pre-requisite for regulating CO<sub>2</sub> emissions from HDVs, while improving the transparency and information on emissions and fuel consumption.</p>
<p>(2) The revised report adds information on basic assumptions behind the calculations on expected savings. The report sees major untapped opportunities in fuel saving technical progress in the vehicle industry and in cost reduction by trucking companies. It could better explain what causes inertia on the side of the trucking industry in developing fuel saving new technologies, and how transport market uncertainties lead operators to underinvest in new low</p>	<p>See reply above under the main RSB consideration.</p>

emission technologies.

The Board takes note of the quantification of the various costs and benefits associated with the different target level options of this initiative, as assessed in the report considered by the Board and summarised in the attached quantification tables.

### 1.3 External expertise

Further information was gathered through support studies commissioned from external contractors<sup>1</sup> and involving the JRC<sup>2</sup>, in particular addressing the following issues:

- the available technologies that can be deployed in the relevant time period to reduce new HDV CO<sub>2</sub> emissions, as well as their effectiveness and cost;
- elements potentially impacting industrial competitiveness and employment;
- the impact of different regulatory approaches, regulatory metrics and possible design elements (modalities);
- impacts on GHG and pollutant emissions.

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<sup>1</sup> In particular "Heavy Duty Vehicles - support for preparation of impact assessment for CO<sub>2</sub>", study by TNO, TUG, CE Delft and ICCT, report to be published

<sup>2</sup> "Heavy Duty Vehicles CO<sub>2</sub> Emission Reduction Cost Curves and Cost Assessment – enhancement of the DIONE model", to be published

## 2 ANNEX 2: STAKEHOLDER CONSULTATION

### 2.1 Introduction

Stakeholders' views have been an important element of input to the preparation of legislative action in the area of CO<sub>2</sub> emissions from Heavy Duty Vehicles (HDVs). The main purpose of the consultation was to verify the accuracy of the information available to the Commission and to enhance its understanding of the views of stakeholders with regard to different aspects of the possible future regulatory framework on CO<sub>2</sub> emissions from HDVs.

A mapping of stakeholders at the initial stages of the impact assessment allowed identifying the following relevant stakeholder groups:

- Member States (national, regional authorities)
- Individual vehicle manufacturers and associations of vehicle manufacturers
- Automotive component suppliers and their associations
- Vehicle fleet operators and their associations
- Environmental non-governmental organisations
- Federations or associations of fuel and manufacturing industries
- Transport and logistics federations or associations
- Purchaser and user organisations (leasing companies, drivers associations, consumer groups, etc.)
- Social partners

The Commission sought feedback from stakeholders through the following elements:

- a public on-line consultation (20 November 2017 until 29 January 2018)
- a stakeholder workshop (16 January 2018);
- meetings with relevant industry associations representing vehicle manufacturers, components and materials suppliers, fuel suppliers.
- meetings with Member State authorities, vehicle manufacturers, suppliers, social partners and NGOs;
- position papers submitted by stakeholders or Member States.

The feedback received at the stakeholder event organised on 16 January 2018 was generally in line with stakeholders' views as submitted to the public consultation.

## 2.2 Public consultation

### 2.2.1 Process and quantitative results

An on-line public consultation was carried out between 20 November 2017 and 29 January 2018 on the EU Survey website<sup>3</sup>. The consultation addressed the following key issues, reflecting the key elements of the impact assessment:

- Main problem to be addressed
- The need for EU action
- Main policy objectives
- Form that action should take to reduce HDV CO<sub>2</sub> emissions
- Options to consider for regulating CO<sub>2</sub> emissions of HDV
- Governance - HDV CO<sub>2</sub> certification and real driving emissions

The results of the public consultation are presented below for each key element. The replies are differentiated across stakeholder groups and summarised as factually as possible. The summary considers diverging views between or within stakeholder groups.

The consultation received 88 replies in total. Most responses were received from professional organisations (37 or 42%) followed by private enterprises (19 or 22%). Civil society organisations submitted 11 replies (13%) and public authorities and individuals (8 or 9% each). Three replies (3%) were received from research institutions. Two “other” submissions were submitted by a Horizon 2020 research project and a public enterprise.<sup>4</sup>

Professional organisations comprised national and EU level associations representing mainly vehicle manufacturers, fuel industry and logistics operators. Private enterprises included mainly automotive component suppliers and vehicle manufacturers. Civil society organisations included environmental and/or transport NGOs. Public authorities included national and regional ministries as well as one city council. Table 1 summarises the distribution of respondents by category.

**Table 1: Distribution of respondents by category**

Category	Number of respondents	Percentage of total number of respondents
Academic / Research institution	3	3%
Civil society organisation	11	13%
Individual / private person	8	9%
International organisation	0	0%
Private enterprise	19	22%
Professional organisation	37	42%

<sup>3</sup> [https://ec.europa.eu/clima/consultations/articles/0031\\_en](https://ec.europa.eu/clima/consultations/articles/0031_en).

<sup>4</sup> In 13 cases the originally indicated “capacity” under which the reply was submitted was manifestly wrong and therefore had to be corrected. In 7 cases it had to be changed from “other” to “professional organisation”, in 1 case from “civil society organisation” to “professional organisation”, in 3 cases from “international organisation” to “professional organisation”, in 2 cases from “international organisation” to “civil society organisation”.

Category	Number of respondents	Percentage of total number of respondents
Public authority	8	9%
Other	2	2%
<b>Total</b>	<b>88</b>	<b>100%</b>

Most responses were submitted from stakeholders based in Belgium (22), followed by Germany (17), the United Kingdom and Sweden (7 each), the Netherlands (6), Denmark (5), France (4) as well as Spain, Italy, Hungary, Finland (3 each) and Poland, Czech Republic (2 each) and Austria, Ireland, Portugal (1 each). Three responses were received from stakeholders that were based outside the EU: Canada (1), Norway (1), and the United States (1).

### 2.2.2 Replies to key issues

#### *Main problem to be addressed*

Concerning the main problem to be addressed, **the majority of stakeholders considered the growing GHG emissions from the HDV sector as “very important” or “important”**. It was considered “very important” by all civil society organisations and all public authorities as well as professional organisations representing the fuels industry. Professional organisations representing manufacturers and component suppliers considered this problem mostly “important”, whereas the increasing competitiveness challenges for vehicle manufacturers was considered by them as “very important”. Few stakeholders across all stakeholder groups considered the fact that transport operators and their clients miss out on possible fuel savings and reduced fuel bills as more important in comparison to the other two problems.

When asked if other key problems should be addressed, stakeholders representing the gas sector pointed to risks related to high levels of air pollutants such as NO<sub>x</sub> and PM. A few stakeholders representing vehicle manufacturer associations underlined the importance of a credible baseline for CO<sub>2</sub> limits based on VECTO as well as the need for an integrated approach that looks also at the efficient use of HDVs. One civil society organisation pointed to the need to decrease traffic.

#### *The need for EU action*

While more stakeholders considered it likely rather than unlikely that Member States would individually implement legislation to reduce HDV CO<sub>2</sub> emissions in the absence of EU action, a considerable number of respondents were neutral on that point. However, a clear majority of all respondents across all stakeholder groups expect that **national legislation would lead to market fragmentation and higher costs** (78% of all replies) and that **Member States would have difficulty to achieve the necessary reductions to meet EU climate goals** (73% of all replies). Concerning other potential effects in the absence of EU action, several stakeholders representing different sectors pointed to possible negative consequences at the international level, e.g. barriers to trade, EU’s loss of technological leadership, and non-EU Member States that follow EU level action would also not take action to reduce HDV CO<sub>2</sub> emissions.

#### *Main policy objectives*

**Reducing the climate impact of HDVs was clearly identified as the main policy objective by all stakeholder groups** (“very important” in 78% of all replies; “important” in 16% of all replies). The second most important policy objective across all stakeholder groups was to facilitate a reduction in the total cost of ownership for transport operators (“very important” in 48% of all replies; “important” in 31% of all replies). The policy objective to contribute to the improvement of the competitiveness of the European HDV and component manufacturers was considered highly important by the majority of stakeholders (“very important” in 32% of all replies; “important” in 41% of all replies). In terms of other key objectives, some stakeholders representing the gas sector referred to the promotion of alternative powertrains and alternative fuels. Some vehicle manufacturer associations underlined the need for a stable legislative framework, whereas a logistics operators association and a vehicle manufacturers association suggested increased market transparency as a key policy objective.

#### *Form that action should take to reduce HDV CO<sub>2</sub> emissions*

When asked, by order of importance, which were their preferred options to reduce CO<sub>2</sub> emission from new HDVs and to contribute to the 2030 energy and climate targets, **the preferred option across all stakeholders was legislation setting HDV CO<sub>2</sub> emission targets at EU level** (1<sup>st</sup> priority for 45% of all respondents and 2<sup>nd</sup> priority for 23% of all respondents).

However, while all civil society organisations favour binding HDV CO<sub>2</sub> targets at EU level, **some stakeholders representing vehicle manufacturers and automotive suppliers preferred other policy options** via a comprehensive approach including legislation defining a CO<sub>2</sub> labelling scheme at EU level, inclusion of the transport sector in the EU Emissions Trading Scheme, other incentives such as fuel taxes at national level, or CO<sub>2</sub> based road charging.

While the setting up of CO<sub>2</sub> emission standards for HDVs is not the preferred option expressed by manufacturers, they have proposed to implement 2025 and 2030 CO<sub>2</sub> emission targets at the lower range of the options considered.

It is to be noted that manufacturers of light- and heavy-duty vehicles have a similar attitude and are generally reluctant to the setting of overly ambitious emission performance standards. Nevertheless CO<sub>2</sub> emission standards for cars and vans have been introduced worldwide and the effect of these standards on the environment and for final consumers have been positive.

In view of these positive developments in the light-duty sector, significant markets such as the US, Canada, China, Japan, India and Mexico have in recent years implemented fuel consumption and/or emission standards for HDVs.

**The least preferred option (except for “no action”) across all stakeholder groups was a voluntary agreement with industry**, followed by Member State actions to influence vehicle choice and use in other ways such as labelling schemes based on VECTO or best practice dissemination.

#### *Options to consider for regulating CO<sub>2</sub> emissions of HDV*

##### Basic regulatory approach

Across all stakeholder groups there was a **clear preference for CO<sub>2</sub> emission standards for the whole vehicle based on VECTO simulations** (1<sup>st</sup> preference in 49% of all replies; 2<sup>nd</sup> preference in 34% of all replies) except for a **civil society organisation**



**which preferred separate CO<sub>2</sub> emission standards for engines and complete vehicles.** Stakeholders preferring a whole-vehicle approach underlined the importance of addressing the problem holistically in order to exploit the most cost-effective CO<sub>2</sub> reduction potential of a vehicle. Civil society organisation referred to the limited regulatory burden for engine standards and the high emission reduction potential. **CO<sub>2</sub> emission standards defined for the engines only was the least preferred option.** In support of this option it was argued that it would allow also covering vocational vehicles which would not be possible under whole-vehicle standards due to the complexity of these vehicles. As regards other possible options for the basic regulatory approach, stakeholders from the gas sector argued for a Well-To-Wheel approach and several civil society organisations were in favour of a zero-emission vehicle mandate or benchmark.

#### Types of targets

**Average targets per vehicle group on the basis of the vehicles placed on the market by each manufacturer,** i.e. a similar approach as for cars and light commercial vehicles, was the first preference by the majority of stakeholders across all stakeholder groups (66% of all replies). Targets at the level of each individual vehicle where CO<sub>2</sub> emissions would be limited at the level of individual vehicles/engines was the second preferred option. Several stakeholders justified their preference by considering vehicle specific targets as too complex and highlighting the advantage of more flexibility for manufacturers when targets are set for vehicle groups. A few stakeholders argued that real freight efficiency should be taken into account when setting targets.

#### Timing of the targets

**A strong majority across all stakeholder groups preferred fixed dates for applicable targets** (1<sup>st</sup> preference: 66% of all replies) instead of annual reduction targets (1<sup>st</sup> preference: 14% of all replies). Stakeholders justified their preference referring to the need for planning certainty, the necessary lead time for industry to develop the technology taking account of the long product cycle for HDVs.

#### Setting quantitative targets

**The majority across all stakeholder groups was of the opinion that targets should be defined ex-ante by the legislation by relative technology improvements over some baseline** as is done for cars and vans (1<sup>st</sup> preference: 66% of all replies). Only very few stakeholders from all stakeholder groups except civil society organisations and logistics operators prefer target setting on the basis of the performance of a certain percentile of best performing vehicles in a certain year (“top runner” approach) with a minimum yearly target (1<sup>st</sup> preference: 11%). Arguments put forward against the “top runner” approach were that it would not be in line with a technology neutral approach, that “top runner” vehicles would not be representative of the total market and that overall such an approach would be less ambitious.

#### Scope of the legislation

There was **no clear preference across stakeholder groups** on the scope of the legislation. Overall the preferred option was that certain vocational vehicles are excluded from the first regulatory step (1<sup>st</sup> preference: 42% of all replies; 2<sup>nd</sup> preference: 15%). However, considering both the 1<sup>st</sup> and 2<sup>nd</sup> preference, separate targets for vocational vehicles within the 4 main vehicle groups, on the basis of VECTO urban, municipal and construction mission profiles was the preferred option (1<sup>st</sup> preference: 26% of all replies; 2<sup>nd</sup> preference: 53%). While civil society organisations prefer the latter approach pointing

to the risk of loopholes when certain vehicles are excluded from the scope, vehicle manufacturers and component suppliers prefer the former approach underlining the specificity of vocational vehicles.

#### Metric for expressing the target

Overall and in particular among stakeholders representing vehicle manufacturers, automotive component suppliers as well as representatives of the gas sector, **the preferred option for expressing the targets was the metric in terms of g CO<sub>2</sub>/tkm.** The main argument put forward in support of this approach was that it would provide for a better incentive for efficiency improvements since it includes a load related element in the metric reflecting the utilisation of the vehicle. By contrast, **most civil society organisations preferred expressing the targets in g CO<sub>2</sub>/km.** This option was considered more appropriate since manufacturers have no influence on the usage of the vehicles and the weight of the goods transported. Some suggested that default payloads should be part of the new regulatory framework. Stakeholders from the logistics sector and public authorities had mixed views on this. Other options put forward by stakeholders arguing in favour of engine standards was the metric g CO<sub>2</sub>/kWh. Some stakeholders referred to g CO<sub>2</sub>/passenger km for busses.

#### Mission profiles

Respondents did not show a strong preference on how the different mission profiles used in the VECTO simulation should be used for target setting. **Across stakeholder groups there was a slight majority in favour of comparing the targets with a weighted average of the mission profiles** (35 positive replies, 22 negative replies). Some stakeholders in favour of this option argued that this approach would allow for taking account of different driving patterns and payloads. This option was followed by the option to define targets for each mission profile separately (32 positive replies, 31 negative replies) with some respondents arguing that this would contribute to transparency. Applying all four mission profiles to all HDVs was the least preferred option (27 positive replies, 36 negative replies).

#### Utility parameter

**Vehicle manufacturers and automotive component suppliers were mostly in favour of using a utility parameter for defining future targets.** More specifically, some of the stakeholders suggested to use cabin size/length and engine power as utility parameter. By contrast, **civil society organisations were against the use of a utility parameter.** Stakeholders representing logistics operators and the gas sector were neutral on this issue.

#### Cost-effective implementation

**The majority of stakeholders across all stakeholder groups was in favour of all proposed options** (pooling, banking and borrowing, trading, transfer of credits between vehicle groups) to support the cost-effective implementation of the targets. Some argued that a credit system is necessary since not all technologies can be fitted in all vehicle categories and such system would therefore allow for cost-effective target compliance. However, **civil society organisations supported trading only** and argued that the other options may undermine the legislation if, for example, manufacturers would invest in efficiency improvements in one vehicle category only.

#### Governance - HDV CO<sub>2</sub> certification and real driving emissions

**A clear majority across all stakeholder groups was of the opinion that it would be important to develop processes assessing the certified CO<sub>2</sub> emissions against real driving emissions** (68% of all replies). Only some automotive component suppliers and vehicle manufacturers were either neutral or explicitly against. They emphasised the specific characteristics of lorries making real-driving tests difficult. However, most automotive component suppliers and vehicle manufacturers were against – or to a lesser extent neutral – the introduction of an ex-post feedback mechanism requiring compliance of the certified CO<sub>2</sub> emissions with real-driving emissions. Such an ex-post feedback mechanism was supported by logistics operators, vehicle fleet operators, and civil society organisations.

### **2.3 Use of the stakeholder input for the impact assessment**

Stakeholder input received during the stakeholder consultation was an important tool during the impact assessment. The results from the analysis of the stakeholder input have been used to develop and assess the policy options. Statements or positions brought forward by certain stakeholders have been clearly highlighted as such.

### 3 ANNEX 3: WHO IS AFFECTED BY THE INITIATIVE AND HOW

#### 3.1 Practical implications of the initiative

The following key target groups of this initiative have been identified.

- HDV manufacturers
- Suppliers of components and materials from which vehicles are constructed
- HDV users (transport operators)
- Suppliers of fuels
- Workforce in automotive sector
- Other users of fuel and oil-related products (e.g. chemical industry, heating)
- Society at large

Table 2 summarises how these target groups are affected by this policy initiative. In some cases the analysis showed overlaps between identified target groups (e.g. vehicle manufacturers and suppliers of components and materials) as a result of which certain effects may be repeated.

**Table 2: Overview of how stakeholders are affected by the policy initiative**

Type of stakeholder	Practical implications
Vehicle Manufacturers	<p><u>Investment needs / manufacturing costs</u></p> <p>CO<sub>2</sub> standards require vehicle manufacturers to reduce CO<sub>2</sub> emissions as a result of which they will have to introduce technical CO<sub>2</sub> reduction measures. In the short-term, this is likely to result in increased production costs and could affect the structure of their product portfolios. As a consequence, they will have increased investment costs for production capacity and new technologies.</p> <p><u>Benefits</u></p> <p>As demand for low carbon vehicles is expected to increase throughout the world due to the development of stricter climate change policies, the introduction of standards will spur manufacturers to become more environmentally efficient. That will ensure they remain at the head of technological development, retaining their competitive position in the global automotive sector.</p> <p><u>Cost / benefits</u></p> <p>There would be different impacts on different manufacturers which depend on the actual reduction level required and the current level of investment and focus by the manufacturer on reducing emissions. The introduction of stricter limits can be positive for those HDV manufacturers who can produce more efficient vehicles as this should enable them to retain their technological leadership position. For manufacturers of HDVs who have to implement more measures to reduce emissions, the costs associated are likely to be larger.</p>

<b>Suppliers of components and materials from which vehicles are constructed</b>	<p><u>Investment costs / new technologies</u></p> <p>Technological advances aimed at improving fuel efficiency will entail costs in research and development as well as in adapting manufacturing processes.</p> <p><u>Benefits</u></p> <p>The competitive position of European component suppliers relative to non-EU competitors might be improved by the introduction of legislative measures to reduce HDV emissions. If EU measures and targets are more ambitious than those in other countries the technology readiness of European companies may be expected to stay ahead that of suppliers based in other countries.</p> <p>Requirements leading to the uptake of additional technologies may create extra business activity for suppliers in these sectors. In particular suppliers for more fuel-efficient technologies will largely benefit.</p>
<b>HDV Users (Transport Operators)</b>	<p><u>Transport costs/prices</u></p> <p>The use of technology to reduce GHG emissions has a cost which is expected to be passed on to the vehicle purchaser. The purchase cost for new more fuel-efficient HDVs is expected to be higher compared to less fuel-efficient vehicles.</p> <p><u>Benefits</u></p> <p>Reducing the vehicle's CO<sub>2</sub> emissions will reduce the energy required and in turn increase fuel cost savings for transport operators. Over the vehicles' lifetime, operational cost savings will compensate the higher procurement costs.</p> <p>If benefits are passed through, lower freight costs could increase overall demand for road freight transport. Depending on the scale of the efficiency improvement, the related benefits and costs, and the level of the pass through this rebound effect could reduce the overall gains in emission reductions from efficiency improvements.</p>
<b>Suppliers of fuels</b>	<p><u>Adjustment costs</u></p> <p>Suppliers of conventional fuels are affected by reduced demand leading to less utilisation of existing infrastructure and possible decrease in revenues..</p> <p><u>Investment needs/Benefits</u></p> <p>If the deployment of vehicles supplied with alternative energy sources lifts up, this may potentially increase the need for other types of infrastructure and create new business opportunities in the medium to long-run.</p>
<b>Workforce in automotive sector</b>	<p>The production and maintenance of vehicles with new, fuel-efficient technologies will pose challenges to the workforce in the automotive sector including manufacturers and component suppliers as well as repair and maintenance businesses. The workforce will need additional and/or different skills ("upskilling" and "reskilling") to deal with new components and manufacturing processes.</p>

<b>Other users of fuel and oil-related products (e.g. chemical industry, heating)</b>	<u>Benefits from reduced oil prices</u> Other users of fuel and oil-related products (e.g. chemical industry, heating) are expected to benefit from lower prices if demand from the transport sector decreases. Sectors other than transport that emit GHGs will avoid demands to further reduce emissions to compensate for increased transport emissions. In so far as these sectors are exposed to competition, this will be important for their competitiveness.
<b>Society at large</b>	<u>Benefits</u> Citizens will benefit from better air quality and less associated health problems due to reduced air pollutant emissions.

### 3.2 Summary of costs and benefits of the different EU fleet-wide CO<sub>2</sub> target level options

Table 3 shows a summary of the main costs and benefits of the different target level options as compared to the corresponding baseline scenario, using the following variables:

- **Net savings per “average” vehicle:** Difference between the fuel savings and the manufacturing costs (see Section 6.2.4.2.2 and Section 6.2.4.2.3 of the Impact Assessment);
- **Manufacturing costs per “average” vehicle:** Additional manufacturing costs in order to reach the targets (equal to the capital costs under a societal perspective (see Section 6.2.4.2.1 of the Impact Assessment);
- **Avoided CO<sub>2</sub> costs per “average” vehicle:** The avoided CO<sub>2</sub> cost is based on the Update of the External Costs of Transport, with a value of 70 €/tonCO<sub>2</sub> for external costs of climate change, averaged over the period 2030-2045<sup>5</sup>
- **NO<sub>x</sub> reduction:** NO<sub>x</sub> emissions (in ktons NO<sub>x</sub>) from road transport with respect to the baseline (see Section 6.2.4.4.3 of the Impact Assessment);
- **PM reduction:** Particulate matter emissions (in ktons PM<sub>2.5</sub>) from road transport with respect to the baseline (see Section 6.2.4.4.3 of the Impact Assessment);
- **GDP:** Change of Gross Domestic Product in 2025 and 2030 with respect to the baseline (see Section 6.2.4.2.6 of the Impact Assessment);
- **Employment:** Change of number of persons employed in the EU-28 in 2025 and 2030, expressed in percentage with respect to the baseline (see Section 6.2.4.2.6 of the Impact Assessment) .

"n.a." indicates that the data were not available from the analysis.

<sup>5</sup> <https://ec.europa.eu/transport/sites/transport/files/themes/sustainable/studies/doc/2014-handbookexternal-costs-transport.pdf>

**Table 3: Summary of costs and benefits of different target level options for the base and high cost assumptions**

2025 Base cost assumptions	Costs	Benefits							
		Net Savings			Environmental			Macro-economic	
Target Level option	Manufacturing costs EUR/lorry	Societal perspective EUR/lorry	TCO first use EUR/lorry	TCO second use EUR/lorry	Avoided CO <sub>2</sub> costs EUR/lorry	NO <sub>x</sub> % reduction	PM % reduction	GDP % increase	Employment % increase
TL20	858	8,137	7,323	5,413	1,240	-0,3%	-0,1%	0,00%	0,00%
TL30NL	1,770	16,627	14,664	10,846	2,626	-0,4%	-0,1%	0,01%	0,01%
TL30	3,088	27,525	23,438	17,354	4,668	-0,5%	-0,1%	0,02%	0,01%
TL32	4,492	34,820	29,659	21,950	6,054	-0,6%	-0,1%	0,02%	0,02%
TL35	7,339	44,200	37,589	27,794	8,169	-0,8%	-0,1%	0,03%	0,02%

2025 High cost assumptions	Costs	Benefits							
		Net Savings			Environmental			Macro-economic	
Target Level option	Manufacturing costs EUR/lorry	Societal perspective EUR/lorry	TCO first use EUR/lorry	TCO second use EUR/lorry	Avoided CO <sub>2</sub> costs EUR/lorry	NO <sub>x</sub> % reduction	PM % reduction	GDP % increase	Employment % increase
TL20	3,077	14,341	12,757	9,408	2,626	-0,4%	-0,1%	0.00%	0.02%
TL30NL	6,344	22,934	20,871	15,358	4,376	-0,6%	-0,1%	n.a.	n.a.
TL30	10,800	28,687	26,337	19,329	6,127	-0,8%	-0,1%	0.01%	0.03%
TL32	17,720	32,455	30,997	22,637	7,805	-1,0%	-0,2%	n.a.	n.a.
TL35	27,797	32,326	33,002	23,905	9,555	-1,3%	-0,2%	n.a.	n.a.

2030 Base cost assumptions	Costs	Benefits							
		Net Savings			Environmental			Macro-economic	
Target Level option	Manufacturing costs EUR/lorry	Societal perspective EUR/lorry	TCO first use EUR/lorry	TCO second use EUR/lorry	Avoided CO <sub>2</sub> costs EUR/lorry	NO <sub>x</sub> % reduction	PM % reduction	GDP % increase	Employment % increase
TL20	4,657	34,736	30,339	22,032	6,831	-1,3%	-0,2%	0.03%	0.02%
TL30 *	19,291	63,071	58,005	41,805	14,289	-3,2%	-0,4%	0.09%	0.05%
TL32	26,572	64,308	60,772	43,608	15,820	-3,9%	-0,5%	0.11%	0.06%
TL35	33,185	69,608	72,120	51,630	17,670	-4,7%	-0,6%	0.14%	0.08%

\* Results for TL30NL are very similar to those for TL30

2030 High cost assumptions	Costs	Benefits							
		Net Savings			Environmental			Macro-economic	
Target Level option	Manufacturing costs EUR/lorry	Societal perspective EUR/lorry	TCO first use EUR/lorry	TCO second use EUR/lorry	Avoided CO <sub>2</sub> costs EUR/lorry	NO <sub>x</sub> % reduction	PM % reduction	GDP % increase	Employment % increase
TL20	13,721	35,120	33,128	23,793	8,479	-1,9%	-0,3%	0.01%	0.05%
TL30 *	47,618	43,436	54,771	38,499	15,624	-4,2%	-0,6%	0.02%	0.09%
TL32	52,073	49,125	65,853	46,394	17,116	-4,9%	-0,7%	n.a.	n.a.
TL35	58,760	57,644	82,429	58,200	19,319	-5,4%	-0,8%	n.a.	n.a.

\* Results for TL30NL are very similar to those for TL30



## 4 ANNEX 4: ANALYTICAL MODELS USED IN PREPARING THE IMPACT ASSESSMENT

The analytical work underpinning this Impact Assessment uses a series of models: PRIMES-TREMOVE, JRC DIONE and EXIOMOD. They have a successful record of use in the Commission's transport, energy and climate policy impact assessments – including for the 2020 climate and energy package, the 2030 climate and energy policy framework, the Effort Sharing Regulation (ESR), the Energy Efficiency Directive (EED) and the Renewable Energy Directive (RED) proposals, the analytical work underpinning the Low-Emission Mobility Strategy and the proposal for the post-2020 CO<sub>2</sub> emission standards for cars and vans.

A brief description of each model is provided below.

### 4.1 PRIMES-TREMOVE transport model

PRIMES-TREMOVE is a private model that has been developed and is maintained by E3MLab/ICCS of the National Technical University of Athens, based on, but extending features of the open source TREMOVE model developed by the TREMOVE modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model. Other parts, like the component on fuel consumption and emissions, follow the COPERT model. When used as a module which contributes to a broader PRIMES scenario, it can show how policies and trends in the field of transport contribute to economy-wide trends in energy use and emissions.

As module of the PRIMES energy system model, PRIMES-TREMOVE has been successfully peer reviewed, most recently in 2011. PRIMES-TREMOVE has been used for the 2011 White Paper on Transport, Low Carbon Economy and Energy 2050 Roadmaps, the 2030 policy framework for climate and energy and more recently for the ESR, the review of the EED, the recast of the RED, the European strategy on Low-Emission Mobility and the proposal for the post-2020 CO<sub>2</sub> emission standards for cars and vans.

The PRIMES-TREMOVE transport model projects the evolution of demand for passengers and freight transport by transport mode and transport mean. It is a dynamic system of multi-agent choices under several constraints, which are not necessarily binding simultaneously.

PRIMES-TREMOVE is suitable for modelling soft measures (e.g. eco-driving, deployment of Intelligent Transport Systems, labelling), economic measures (e.g. subsidies and taxes on fuels, vehicles, emissions, pricing of congestion and other externalities such as air pollution, accidents and noise; measures supporting R&D), infrastructure policies for alternative fuels (e.g. deployment of refuelling/recharging infrastructure for electricity, hydrogen, LNG, CNG) and regulatory measures.

Regulatory measures include EU Regulations No 443/2009 and No 510/2011 setting CO<sub>2</sub> emission performance standards for new passenger cars and new light commercial vehicles.

PRIMES-TREMOVE simulates the equilibrium of the transport market. It has a modular structure, featuring a module projecting demand for transportation services for passenger and freight mobility and a supply module deriving ways of meeting the demand.

The supply module projects the optimum technology and fuel mix to produce transportation services which meet demand. It includes a vehicle stock sub-module which

considers stock of transport means inherited from previous time periods and determines the necessary changes to meet demand.

PRIMES-TREMOVE tracks vehicle vintages and formulates the dynamics of vehicle stock turnover by combining scrapping and new registrations.

The supply module of PRIMES-TREMOVE interacts with the demand module through the so-called generalised prices of transportation (measured in Euro per passenger/ton km). Different generalised prices are calculated for the various alternative trip possibilities included in the decision tree of the demand module (e.g. area, time, distance) by transport mode. When the generalised prices differ from the baseline scenario, the model determines the new demand (for each of the various possible trips) based on the price differential relative to the baseline scenario and the elasticities of substitution (different among the various options) by respecting the overall budget (micro-economic foundation).

Regarding the purchasing of new vehicles, a menu of technology options is considered; for lorries, the available technology portfolio includes different configurations, different technologies having an impact on fuel consumption and fuel types. The purchase choice of lorries follows the approach of discrete choice modelling. A Weibull functional form is used to determine the frequency of choice of a certain lorry. The cost indices entering the Weibull function include several elements in two main categories: (1) internal costs, (2) perceived costs, i.e. market acceptance for each technology, (3) infrastructure availability.

Internal costs (true payable costs) include all cost elements over the lifetime of the candidate transport means: purchasing cost, annual fixed costs for maintenance, insurance and ownership/circulation taxation, variable costs for fuel consumption depending on trip type and operation conditions, other variable costs including congestion fees, parking fees and tolled roads.

Market acceptance factors are used to simulate circumstances where vehicle operators have risk avert behaviours regarding new technologies when they are still in early stages of market deployment. Perception of risk usually concerns technical performance, maintenance costs and operation convenience. When market penetration exceeds a certain threshold, operators imitating each other change behaviour and increasingly accept the innovative technologies giving rise to rapid market diffusion. Therefore, the model simulates reluctance to adopt new technologies in early stages of diffusion and more rapid market penetration in later stages.

The PRIMES-TREMOVE model has been adapted to be able to simulate in a more detailed way the various lorry vehicle/family groups that are influenced by the future targets. The lorry categories considered refer to combinations of rigid lorries and tractors with 4x2 or 6x2 axles for regional delivery or long-haul purposes.

The model simulations assume that the relative share of lorries in the different vehicle groups, i.e. rigid lorries and tractors with 4x2 and 6x2 axles, is kept constant through the entire period of simulation. The respective shares have been calibrated into PRIMES-TREMOVE on the basis of 2016 production data collected from the manufacturers in 2017.

This approach reflects the fact that the choice of a certain vehicle configuration according to the criteria defining the groups is mainly determined by the specific transport purpose,

which is relatively constant over time, and the transport utility of lorries of different groups is not easily exchangeable.

When a CO<sub>2</sub> target for lorries is set, a representative seller is assumed to offer to the market a variety of vehicles having different technologies installed, leading to different prices and CO<sub>2</sub> emissions, which on average have to respect the target.

The assumptions on the costs and CO<sub>2</sub> emission reduction potential of new lorries have been updated, for the purposes of this impact assessment, to the most recent available information. The cost-emission reduction potential differs by the various lorry vehicle groups under consideration.

The average performance against the standard is endogenously calculated depending on consumer choice of vehicle types. When a target applies, the average performance of the new fleet has to respect the value of the target. Otherwise, an iterative algorithm is set in motion that increases the costs of the non-complying vehicles, as if the representative seller was aiming to improve the competitive advantage of the vehicles that comply with the target. This cost increase is estimated endogenously and depends on the difference between the value of the standard and the CO<sub>2</sub> emission performance of the particular vehicle. This procedure is repeated until average performance of the new fleet meets the value of the standard.

The lorries segment as represented in the PRIMES-TREMOVE include the following options by fuel type: diesel, LNG, hydrogen, electricity. Due to the currently unknown prospects of zero-emission lorries, and the uncertainty prevailing over the commercial maturity of such vehicle options, ZEV fail to penetrate in the PRIMES-TREMOVE projections over the time horizon under consideration in this impact assessment.

Any effects coming from zero-emission lorries, e.g. on the total CO<sub>2</sub> emissions of the fleet, therefore have to be calculated externally to PRIMES-TREMOVE. For the lorry categories with a gross vehicle weight > 16 t, PRIMES-TREMOVE simulations indicate that diesel and LNG lorries are expected to be the most relevant lorry technology/fuel options in the time period until 2030. The decision-making in the model is also influenced by the availability of refuelling infrastructure for LNG vehicles. This relates to sufficient availability on the market of LNG fuel as well as supply infrastructure alike.

The current EURO standards on road transport vehicles are explicitly implemented and are important for projecting the future volume of air pollutants in the transport sector and determining the structure of the fleet.

The PRIMES-TREMOVE projections, used for the analysis presented in Section 6 of the Impact Assessment, include details for a large number of transport means, technologies and fuels (both conventional and alternative types), and their penetration in various transport market segments. They include details about greenhouse gas and air pollution emissions (e.g. NO<sub>x</sub>, PM, SO<sub>x</sub>, CO), final energy demand.

## **4.2 DIONE model (JRC)**

The DIONE model suite is developed, maintained and run by the JRC. It has been used for the assessment of HDV capital and operating costs presented in Chapter 6 of the Impact Assessment. Different computational modules have been developed previously to support the assessment of policy options for light-duty vehicle CO<sub>2</sub> emission reduction,

and have been documented in detail in Krause et al (2017)<sup>6</sup>. The following DIONE modules have been modified and employed for the present analysis:

- DIONE Cost Curve Model
- DIONE Cross-Optimization Module
- DIONE Fuel and Energy Cost Module
- DIONE TCO Module

The DIONE Cost Curve Model was used for developing HDV CO<sub>2</sub> reduction cost curves. They provide a continuous functional description of the costs associated with reaching given CO<sub>2</sub> reductions for the different HDV classes and powertrains.

Cost curves were developed for 8 HDV sub-groups (VECTO groups 4, 5, 9 and 10, each with a long haul and regional delivery focused driving pattern, respectively), for diesel and liquid natural gas (LNG) powertrains, and for the years 2025 and 2030. The cost curve model needs input data on available technologies, their CO<sub>2</sub> reduction potentials and costs, as well as their compatibility. This input data was provided by Commission consultants.

Two versions of cost curves were developed, one ‘base’ set of curves based on the best available information as collected by the consultants, and one ‘high’ set of curves which took on board information received from manufacturers after the presentation of the first set of curves.

On the basis of the cost curves, the DIONE Cross-Optimization Module was run to determine the optimal (i.e. technology cost minimizing) CO<sub>2</sub> reduction for each HDV group, powertrain and year, given the relevant CO<sub>2</sub> targets and fleet compositions for different scenarios. The fleet compositions were taken from the PRIMES-TREMOVE runs.

As the standard cost curves have positive first and second derivatives, this is a mathematical problem that can be solved by a standard optimization algorithm. For the present analysis, a second cross-optimization option was implemented to identify the optimal distribution of CO<sub>2</sub> reduction efforts from a societal perspective, i.e., with regard to minimizing additional manufacturing costs minus fuel savings gained through HDV efficiency improvement.

Moreover, while previously optimization was carried out over all classes within a fleet, a new mechanism was implemented to allow setting separate targets for each HDV sub-group. Outputs from the Cross-Optimization Module are optimal CO<sub>2</sub> reductions ( $x_{opt}$ ) per HDV group and powertrain and the corresponding manufacturing costs ( $c_{opt}$ ), which represent the capital costs shown in Chapter 6 of the Impact Assessment.

In the Fuel and Energy Cost Module, fuel costs per powertrain and HDV group are calculated taking into account the scenario specific vehicle energy consumption as well as vehicle mileages and fuel prices. Vehicle mileages per HDV group as well as mileage profiles over vehicle lifetime are based on data analysis provided by Commission consultants. Fuel prices are aligned with PRIMES-TREMOVE. They are discounted and

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<sup>6</sup> Krause, J., Donati, A.V., Thiel, C., Light Duty Vehicle CO<sub>2</sub> Emission Reduction Cost Curves and Cost Assessment - the DIONE Model, EUR 28821 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-74136-4, doi:10.2760/87837, JRC108725

weighted by vehicle class activity over vehicle age, such that they can be used as multipliers within the calculation.

In the DIONE TCO (total cost of ownership) Module, technology costs and fuel costs are aggregated, discounted and weighted where appropriate, to calculate total costs of ownership from the perspectives of first and second end-uses as well as society.

### 4.3 Macro-economic model - EXIOMOD

The EXIOMOD model - EXtended Input-Output MODEL - was developed by TNO. It is a large scale and highly detailed world model built on the detailed Input-output database EXIOBASE<sup>7</sup> for the purpose of measuring the environmental and economic impacts of policies<sup>8</sup>.

EXIOMOD is a macro-economic ‘computable general equilibrium’ (CGE) model that divides the global economy in 44 countries and a Rest of World, 129 industry sectors per country, 200 products and various environmental indicators (see Table 4).

**Table 4: Environmental indicators covered in the EXIOBASE v3 database**

Indicator	Level of detail	Examples
Emissions in kg	31 GHG and non GHG emissions	<ul style="list-style-type: none"> <li>• CO<sub>2</sub></li> <li>• CH<sub>4</sub></li> <li>• NH<sub>3</sub></li> </ul>
Land use in ha	12 types of agricultural land use	<ul style="list-style-type: none"> <li>• Arable land used for rice</li> <li>• Arable land used for wheat</li> <li>• Arable land used for sugar crops</li> </ul>
Resource use in kg	165 types of crops	<ul style="list-style-type: none"> <li>• Soybeans</li> <li>• Almonds</li> <li>• Cocoa beans</li> </ul>
	8 types of non-metallic minerals	<ul style="list-style-type: none"> <li>• Slate</li> <li>• Gravel and sand</li> <li>• Salt</li> </ul>
	9 types of fossil fuels	<ul style="list-style-type: none"> <li>• Anthracite</li> <li>• Peat</li> <li>• Crude oil</li> </ul>
	10 types of metals	<ul style="list-style-type: none"> <li>• Iron</li> <li>• Copper</li> <li>• Lead</li> </ul>
Water use in Mm <sup>3</sup>	<ul style="list-style-type: none"> <li>• Consumption green</li> <li>• Consumption blue</li> <li>• Withdrawal blue</li> </ul>	

The model is presently calibrated on the data for year 2011. The model is dynamic and uses the period 2050 as the time horizon for its calculations with one year increment time steps.

<sup>7</sup> [www.exiobase.eu](http://www.exiobase.eu)

<sup>8</sup> For a full description and examples of applications of EXIOMOD see Bulavskaya, Hu, Moghayer, & Reynès (2016).

Computable General Equilibrium (CGE) models (and in particular EXIOMOD) are the class of simulation tools that use large datasets of real economic data in combination with complex computational algorithms in order to assess how the economy reacts to changes in governmental policy, technology, availability of resources and other external macro-economic factors.

EXIOMOD model consists of (1) the system of non-linear equations, which describes the behaviour of various economic actors and (2) very detailed database of economic, trade, environmental and physical data. The core part of the model database is the Social Accounting Matrix, which represents in a consistent way all annual economic transactions.

A CGE model accounts for the interaction/feedbacks (a) between price and demand/supply quantities and (b) between economic agents at the macro and sectorial level. Therefore, it gives the economic relations between all industry sectors via their intermediate use.

For the purposes of the present Impact Assessment EXIOMOD is used to quantify the macro-economic impacts of different CO<sub>2</sub> targets for HDVs on the wider economy, i.e. GDP, sectoral turnover, employment, net-export. The modelled scenarios use input from PRIMES-TREMOVE, in particular fuel consumption from HDV's, annuity payments for capital costs for road transport vehicles, new registration for total road transport and new registrations of road transport vehicles. These input parameters are used to fix corresponding variables in EXIOMOD, and quantify the impact of the modelled scenarios on other sectors of the economy.

#### **4.4 Baseline and policy scenarios**

The Baseline and policy scenarios used in this impact assessment build for most of their parts on the EU Reference scenario 2016, as it was established at the end of 2014, but additionally include a few more recently adopted policy measures and some updates in the technology costs assumptions.

Building an EU Reference scenario is a regular exercise by the Commission. It is coordinated by DGs ENER, CLIMA and MOVE in association with the JRC, and the involvement of other services via a specific inter-service group.

For the EU Reference scenario 2016, Member States were consulted throughout the development process through a specific Reference scenario expert group which met three times during its development. Member States provided information about adopted national policies via a specific questionnaire, key assumptions have been discussed and in each modelling step, draft Member State specific results were sent for consultation. Comments of Member States were addressed to the extent possible, keeping in mind the need for overall comparability and consistency of the results.

Quality of modelling results was assured by using state of the art modelling tools, detailed checks of assumptions and results by the coordinating Commission services as well as by the country specific comments by Member States.

The EU Reference scenario 2016 projects EU and Member States energy, transport and GHG emission-related developments up to 2050, given current global and EU market trends and adopted EU and Member States' energy, transport, climate and related relevant

policies. "Adopted policies" refer to those that have been cast in legislation in the EU or in Member States (with a cut-off date end of 2014<sup>9</sup>). Therefore, the binding 2020 targets are assumed to be reached in the projection. This concerns GHG emission reduction targets as well as renewables targets, including renewable energy in transport.

Initiatives supporting the shift from road to rail transport are complementary to the improvement of energy efficiency of HDVs for the sake of reducing CO<sub>2</sub> emissions of the overall freight transport sector. Modal shifts between road and rail on the basis of the 2016 regulatory situation are reflected in the "EU reference scenario" and have been considered for the purposes of the modelling work.

The EU Reference scenario 2016 provides projections, not forecasts. Unlike forecasts, projections do not make predictions about what the future will be. They rather indicate what would happen if the assumptions which underpin the projection actually occur. Still, the scenario allows for a consistent approach in the assessment of energy and climate trends across the EU and its Member States.

The report "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"<sup>10</sup> describes the inputs and results in detail. In addition, its main messages are summarised in the impact assessments accompanying the Effort Sharing Regulation<sup>11</sup> and the revision of the Energy Efficiency Directive<sup>12</sup>, and the analytical work accompanying the European strategy on low-emission mobility<sup>13</sup>.

The projections are based on a set of assumptions, including on population growth, macroeconomic and oil price developments, technology improvements, and policies.

#### *Specific policy assumptions*

The key policies included in the Baseline scenario, similarly to the EU Reference scenario 2016, are the following:

- CO<sub>2</sub> standards for cars and vans regulations (Regulation (EC) No 443/2009, amended by Regulation (EU) No 333/2014 and Regulation (EU) No 510/2011, amended by Regulation (EU) No 253/2014): CO<sub>2</sub> standards for cars are assumed to be 95 gCO<sub>2</sub>/km as of 2021 and for vans 147 gCO<sub>2</sub>/km as of 2020, based on the NEDC test cycle, in line with current legislation. No policy action to strengthen the stringency of the target is assumed after 2020/2021.
- The Renewable Energy Directive (Directive 2009/28/EC) and Fuel Quality Directive (Directive 2009/30/EC) including ILUC amendment (Directive 2015/1513/EU): achievement of the legally binding RES target for 2020 (10% RES in transport target) for each Member State, taking into account the use of flexibility mechanisms when relevant as well as of the cap on the amount of food or feed based biofuels (7%). Member States' specific renewable energy policies for the heating and cooling sector are also reflected where relevant.

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<sup>9</sup> In addition, amendments to two Directives only adopted in the beginning of 2015 were also considered. This concerns notably the ILUC amendment to the Renewables Directive and the Market Stability Reserve Decision amending the ETS Directive.

<sup>10</sup> ICCS-E3MLab et al. (2016), EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050

<sup>11</sup> SWD(2016) 247

<sup>12</sup> SWD(2016) 405

<sup>13</sup> SWD(2016) 244

- Directive on the deployment of alternative fuels infrastructure (Directive 2014/94/EU).
- Directive on the charging of heavy goods vehicles for the use of certain infrastructures (Directive 2011/76/EU amending Directive 1999/62/EC).
- Relevant national policies, for instance on the promotion of renewable energy, on fuel and vehicle taxation, are taken into account.

In addition, a few policy measures adopted after the cut-off date of the EU Reference scenario 2016 at both EU and Member State level, have been included in the Baseline scenario:

- Directive on weights & dimensions (Directive 2015/719/EU);
- Directive as regards the opening of the market for domestic passenger transport services by rail and the governance of the railway infrastructure (Directive 2016/2370/EU);
- Directive on technical requirements for inland waterway vessels (Directive 2016/1629/EU), part of the Naiades II package;
- Regulation establishing a framework on market access to port services and financial transparency of ports<sup>14</sup>;
- The replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonized Light-vehicles Test Procedure (WLTP) has been implemented in the Baseline scenario, drawing on work by JRC. Estimates by JRC show a WLTP to NEDC CO<sub>2</sub> emissions ratio of approximately 1.21 for cars when comparing the sales-weighted fleet-wide average CO<sub>2</sub> emissions. WLTP to NEDC conversion factors are considered by individual vehicle segments, representing different vehicle and technology categories.
- For Germany, an extension of the toll network by roughly 40,000 kilometres of federal trunk road from 2018 onwards for all heavy goods vehicles over 7.5t.<sup>15</sup>
- For Austria, the incorporation of exhaust emissions and noise pollution in the distance based charges. All federal highways and motorways, totalling around 2,200 km, are subject to distance based charges.
- For Belgium, a distance based system replaced the former Eurovignette for heavy goods vehicles over 3.5t from April 2016. The system applies to all inter-urban motorways, main (national) roads<sup>16</sup> and all urban roads in Brussels.
- For Latvia, the introduction of a vignette system applied for goods vehicles below 3.5t on the motorways, starting with 1 January 2017. In addition, for all heavy goods vehicles over 3.5t the vignette rates applied on motorways for the EURO 0, EURO I, EURO II are increased by 10% starting with 1 January 2017.

#### *Technology cost assumptions*

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<sup>14</sup> Regulation (EU) 2017/352

<sup>15</sup> Currently, 15,000 kilometres of federal trunk road and motorways are subject to tolls.

<sup>16</sup> E.g. <http://www.viapass.be/fileadmin/viapass/documents/download/VlaanderenE.JPG>



For the baseline and policy scenarios of this impact assessment, the technology cost assumptions used were taken from a study prepared by the Commission's consultants<sup>17</sup> and the JRC<sup>18</sup> (base costs) or based on data provided by industry stakeholders (high costs). *United Kingdom*

The Baseline scenario and all policy scenarios cover EU-28, so including the UK. A sensitivity was run under which the UK results were removed from the modelling outcome. This is presented in Annex 10.11.

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<sup>17</sup> "Heavy Duty Vehicles - support for preparation of impact assessment for CO<sub>2</sub>", study by TNO, TUG, CE Delft and ICCT, report to be published

<sup>18</sup> "Heavy Duty Vehicles CO<sub>2</sub> Emission Reduction Cost Curves and Cost Assessment – enhancement of the DIONE model", to be published

## 5 ANNEX 5: INTRODUCTION TO THE IMPACT ASSESSMENT – COMPLEMENTARY INFORMATION

### 5.1 Description of the HDV sector

HDVs are defined as freight vehicles of more than 3.5 tonnes (lorries)<sup>19</sup> or passenger transport vehicles of more than 8 seats (buses and coaches)<sup>20</sup>.

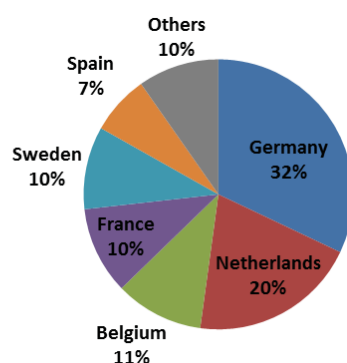
Road freight transport is essential for the development of trade and commerce on the European continent. Lorries carry 71.3% of freight transported over land<sup>21</sup>. Many essential public services are delivered by lorries, such as garbage collection, fire and construction services. There are some 16.5 million lorries in circulation in the EU<sup>22</sup>.

In the EU, almost 3 million people work in the road freight transport sector, with another 3.5 million people employed in lorry manufacturing, repair, sales, leasing and insurance<sup>23</sup>.

The road freight and passenger transport sector largely consists of SMEs, with over 600,000 enterprises across the EU, most of which are very small firms operating just a few lorries or buses/coaches. These include some 554,000 freight transport operators, the remaining being passenger transport operators.

In 2016, around 420,000 HDVs were produced in the EU<sup>24</sup>. As Figure 1 shows, production is concentrated in a few Member States, with Germany accounting for the largest share (32%), followed by the Netherlands (20%), Belgium, France, Sweden and Spain.

**Figure 1: HDV Production in the EU by Member State in 2016**<sup>25</sup>



Source: ACEA Pocket Guide 2017/2018

<sup>19</sup> According to international classifications, N2 and N3 vehicles used for the carriage of goods and having a maximum mass between 3.5 tonnes and 12 tonnes (N2) or exceeding 12 tonnes (N3).

<sup>20</sup> According to international classifications, M2 and M3 vehicles used for the carriage of passengers and comprising more than eight seats in addition to the driver's seat and having a maximum mass not exceeding 5 tonnes (M2) or exceeding 5 tonnes (M3).

<sup>21</sup> European Commission (2017), EU transport in figures – statistical pocketbook 2017, [https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017\\_en](https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2017_en)

<sup>22</sup> [http://www.acea.be/uploads/publications/factsheet\\_trucks.pdf](http://www.acea.be/uploads/publications/factsheet_trucks.pdf)

<sup>23</sup> International Road Transport Union: <https://www.iru.org/who-we-are/about-mobility/trucks>

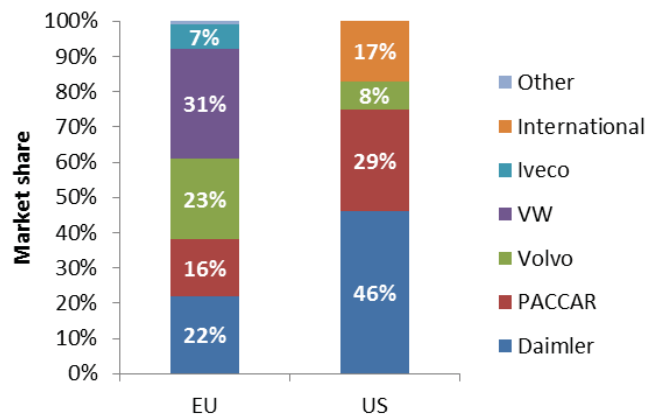
<sup>24</sup> [http://www.acea.be/uploads/publications/factsheet\\_trucks.pdf](http://www.acea.be/uploads/publications/factsheet_trucks.pdf)

<sup>25</sup> Data refers to HDVs over 15 tonnes (including articulated trucks).

In 2016, according to industry data<sup>26</sup>, the export of lorries above 5 tonnes was worth €5.3 billion and generated a trade balance surplus of €4.9 billion. Some of the main export markets for commercial vehicles in 2016 included Hong Kong, U.S., Turkey, Switzerland and Norway.

The EU lorry market is dominated by 6 major manufacturers: Daimler, DAF<sup>27</sup>, M.A.N., Scania, Renault, Volvo and Iveco<sup>28</sup>. Figure 2 shows the breakdown of the EU and US markets by manufacturer. Volkswagen (owning M.A.N. and Scania) has the largest share of the EU market (31%). It shows that several of the HDV manufacturers operating in the EU also have a strong presence in the US market, in particular Daimler (46%), but also PACCAR and Volvo.

**Figure 2: 2014 Market Share of Tractor Lorry Manufacturers in the EU and U.S.**



Source: ICCT (2015)

Figure 3 shows that, compared to the EU and US, the Chinese and Asia-Pacific HDV markets are less consolidated. They are dominated mainly by domestic manufacturers, although some EU companies such as Daimler and Volvo have joint agreements in place in these regions, which are securing them market access<sup>29</sup>.

On a global scale, China is currently the leading producer (30%) of commercial vehicles, followed by North America (23%) and the EU (19%).

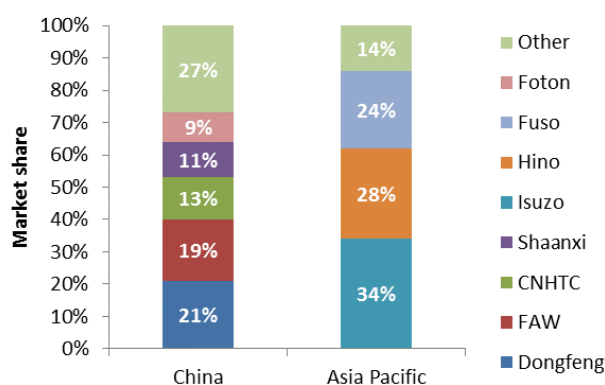
<sup>26</sup> [http://www.acea.be/uploads/publications/factsheet\\_trucks.pdf](http://www.acea.be/uploads/publications/factsheet_trucks.pdf)

<sup>27</sup> Owned by US manufacturer PACCAR

<sup>28</sup> Renault trucks are part of the Volvo Group while M.A.N. and Scania are owned by Volkswagen.

<sup>29</sup> For example, Daimler holds a 90% stake in the Japanese company Fuso, which has a 24% share of the Asia-Pacific market.

**Figure 3: Market Share of Manufacturers of Medium- and Heavy Duty Lorries in China and Asia-Pacific**



Source: Roland Berger (2017) *Truck and trailer components – Success factors for suppliers in specialized markets*

## 5.2 Specificities of the HDV sector compared to LDVs

### *Vehicle design and application, technological options*

Compared to cars (and vans), HDVs are used for a much wider range of commercial and vocational purposes, ranging from urban, regional and long-haul deliveries of goods, to specific applications in the construction sector and municipal services. This implies a large variation in cargo weight and combinations of vehicle components, such as the driver cabin, vehicle body, gearbox, engine, axis and auxiliaries.

The average annual mileages of the vehicles also vary considerably depending on the type of activities, from 70,000 km for regional delivery vehicles to around 140,000 km for long haul vehicles. This results in a very wide range of fuel consumption and CO<sub>2</sub> emissions from lorries, the latter ranging from 690 g CO<sub>2</sub>/km to 1080 g CO<sub>2</sub>/km<sup>30</sup>.

Consequently, the HDV sector is much more diversified, with a significant number of different vehicle types and models as well as with a higher degree of customisation. HDVs (lorries) can be categorised into groups and sub-groups according to their size configuration and mission profile (for more information, see Annex 8).

The production cycle for designing and introducing new models or important features for HDVs, for instance a new generation of engines or cabins, is longer than cars: around 10 to 15 years for lorries and buses, versus 6 to 8 years for cars.

Except for buses, alternative powertrain development is less advanced for heavy-duty vehicles than for cars. Electrification is in very early stages.

### *Availability of certified data*

<sup>30</sup> IEA (2017) *The Future of Trucks – Implications for Energy and Environment*. - 690 g CO<sub>2</sub>/km for HDVs with gross vehicle weight from 3.5 t to 15 t and 1080 g CO<sub>2</sub>/km for HDVs with gross vehicle weight above 15 t

The fuel consumption and CO<sub>2</sub> performance of new passenger cars and vans is determined through emissions type approval on a chassis dynamometer since 1980<sup>31</sup>. As a result, CO<sub>2</sub> emission data at vehicle level has been available for several years.

For HDVs emissions type-approval testing cannot be performed meaningfully through testing on a chassis dynamometer due to the numerous types and configuration of vehicles. Currently, CO<sub>2</sub> data is only available for the engines and not at the whole-vehicle level.

While this knowledge gap is currently being addressed for new HDVs through the VECTO and the new certification legislation (see Annex 8), the first certified CO<sub>2</sub> and fuel consumption data won't be published until 2020. It will cover only part of the groups of lorries. The certification legislation is still work in progress. With regard to buses, which make some 9.3% of total number of HDVs in 2016<sup>32</sup>, smaller lorries and trailers, the certification legislation is not yet even developed. (see Annex 8, Section 0)

Some provisional and estimated CO<sub>2</sub> emissions data for the 2016 fleet has been provided to the Commission by lorries manufacturers to support the analysis carried out for this impact assessment. However, these data were not generated in application of the new certification legislation and are not directly comparable between manufacturers due to the different assumptions made.

As regards real world fuel consumption of individual vehicles, the information available is not directly comparable as it is based on different tests and simulations carried out by HDV manufacturers or specialised journals<sup>33</sup> under non-standardised conditions.

### ***Market structure***

While the EU car market is composed of numerous manufacturers, the EU HDV market only has a small number of major manufacturers, from just a few countries. The scale of the markets is also different with around 420,000 HDVs manufactured in 2016 in the EU versus 16.5 million cars manufactured over the same period.

Also, purchasers of HDVs are mostly businesses, consisting largely of SMEs and micro-enterprises, while the buyers of cars are mainly households. The demand for HDVs can also be very cyclical and subject to prevailing economic conditions. The average age of a lorry in Europe is 11.7 years<sup>34</sup>.

The HDV market is more disaggregated than that of passenger cars in that a lorry manufacturer for the most part is only responsible for the base vehicle but not for the final vehicle configuration which includes the addition of bodies or trailers. In contrast to the manufacturers, the trailer and body builder sector is highly diverse, consisting of thousands of organisations most of which operate in local markets.

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<sup>31</sup> Council Directive 80/1268/EEC of 16 December 1980 on the approximation of the laws of the Member States relating to the fuel consumption of motor vehicles, OJ L 375, 31.12.1980, p. 36–45

<sup>32</sup> Data for 2016, [www.oica.net](http://www.oica.net)

<sup>33</sup> e.g. the German "Lastauto Omnibus"

<sup>34</sup> [http://www.acea.be/uploads/publications/factsheet\\_trucks.pdf](http://www.acea.be/uploads/publications/factsheet_trucks.pdf)

### 5.3 Overview of international HDV CO<sub>2</sub> or fuel economy **standards**

#### *Situation in the US and Canada*

In September 2011, the U.S. adopted regulations on HDV GHG emissions and fuel consumption. The GHG regulations are developed and managed by the Environmental Protection Agency (EPA) and those on fuel consumption by the National Highway Traffic Safety Administration (NHTSA). The drivers behind these legislative measures involved a combination of energy security and environmental protection concerns. The current "Phase I" Regulations run until 2017, after which "Phase II" Regulations will be implemented until 2027.

The Phase I Regulations set standards for new tractors, pickups, vans and all other medium and heavy-duty vehicles of model years 2014 through 2018 and will require manufacturers to improve fuel economy and GHG emissions by up to 20 per cent by 2018. The CO<sub>2</sub> emission standards are set in gram/ton-mile. In addition, the proposal comprises new engine standards for CO<sub>2</sub> (in g/bhp-hr) and fuel consumption.

As the U.S. lorry market allows the vehicle buyer to choose between different engines, a dual approach applying to engine and vehicle emissions was applied. U.S. engines are certified using an engine dynamometer running two different drive test cycles. The standards for whole vehicle emissions and fuel consumption use the GEM simulation model, which has three different drive cycles and a further two idle cycles for vocational vehicles.

Manufacturers must meet the standards each manufacturing year, but there are flexibility options allowing additional lead-time to introduce technologies to the fleet, such as averaging, banking and a trading scheme that also gives credits for early adoption and advanced technologies.

All vehicles must be certified at the point of sale. Testing is carried out either by the EPA or the manufacturer, and also throughout the useful life of the vehicle. Violations and penalties are issued on the basis of this information. There is a single reporting structure in which manufacturers report their sales for the year and their emissions given in the Certificates of Conformity.

Phase II standards, which will take effect from 2018 while becoming increasingly stringent over the coming decade, will regulate not only lorry efficiency but also trailer efficiency.

Canada followed US standards and adopted the same Phase I and Phase II standards.

#### *Situation in China*

In 2012, China put in place a type approval standard (Phase I) in order to establish a benchmark against which to design a subsequent round of emission standards. By 2015, these new standards (Phase II) were applied on all new heavy-duty vehicle sales.

Phase II standards differ by fuel and vehicle type and a step function mandates maximum fuel consumption by gross vehicle weight. Testing is performed on a version of the World Harmonised Transient Vehicle Cycle modified to reflect Chinese on-road conditions.

China's Phase III standards, expected to be introduced between 2019 and 2021, target a reduction in fuel consumption of about 15% in 2020 from 2015 levels.

China regulates new type approvals, conducts conformity of production testing and runs inspection and maintenance programmes as a part of its heavy duty emissions regulation programme. The former two compliance mechanisms are the responsibility of the Ministry of Environmental Protection (MEP). The institution implementing the programmes is the Vehicle Emission Control Centre (VECC) under the MEP.

### ***Situation in Japan***

Japan was the first country to introduce in 2006 a fuel consumption based rule for HDVs, both for energy security reasons and for meeting global climate targets. The standards are given as km/litre and became applicable from April 1st, 2015.

The standards are based on the "Top Runner Programme" which takes the best performing vehicle in the market as the baseline for the standards. For HDVs, the best-in-class vehicles in each category from the model year 2002, plus an additional 12.2% fuel efficiency gain for lorries and 12.1% gain for buses, were used to set the 2015 fleet average fuel efficiency targets. Separate limits were set for 13 categories of lorries and 12 types of buses.

Compliance is determined by use of a computer simulation procedure that calculates fuel efficiency based on engine dynamometer testing. The penalties for non-compliance are relatively loose. The most notable enforcement mechanism is a public announcement by the Authorities, which is considered a severe enough incentive to ensure compliance.

### ***Situation in other countries***

India introduced HDV efficiency standards for vehicles exceeding 12 tonnes in 2017. The standards will apply during the period 2018 – 2021.

Mexico adopted standards for HDVs in 2018. Starting from 2021 onwards, all new HDVs sold in Mexico will be required to meet the best-in-class tailpipe standards, equivalent to the performance of vehicles in North-America.

Among the countries considering the introduction of fuel efficiency and CO<sub>2</sub> standards for HDVs are Russia and South Korea.

## 6 ANNEX 6: POLICY INITIATIVES ADDRESSING TRANSPORT EMISSIONS

### 6.1 Overview of recent Commission initiatives

#### *2016 European Strategy for low-emission mobility*

In 2016, the European Strategy for low-emission mobility reaffirmed the objective of reducing GHG emissions from transport by at least 60% on 1990 level by 2050. At the same time, the Commission proposed 2030 GHG emission reduction targets for the non-ETS sectors for each Member State under the Effort Sharing Regulation<sup>35</sup> and these were recently agreed by the co-legislators. Proposals revising the Energy Efficiency Directive<sup>36</sup> and the Renewable Energy Directive<sup>37</sup> are being discussed in the Council and the European Parliament.

#### *Communication “Europe on the Move” of May 2017*

The Commission's May 2017 Communication 'Europe on the Move'<sup>38</sup>: An agenda for a socially fair transition towards clean, competitive and connected mobility for all' makes clear that ambition is to ensure that the best low-emission, connected and automated mobility solutions, equipment and vehicles will be developed, offered and manufactured in Europe and that we have in place the most modern infrastructure to support them.

#### *Industrial Policy Strategy of September 2017*

In September 2017, the Commission also adopted its Industrial Policy Strategy aimed at promoting sustainable growth and jobs with a focus on innovation, digitization and decarbonisation.

#### *Proposal for a Regulation setting CO<sub>2</sub> emission performance standards for light-duty vehicles for the period up to 2030*

In November 2017, the Commission adopted a Proposal<sup>39</sup> for a Regulation setting CO<sub>2</sub> emission performance standards for light-duty vehicles (cars and vans) for the period up to 2030. These standards will contribute to achieving the targets set out in the Effort Sharing Regulation. However, as indicated in the accompanying impact assessment<sup>40</sup> underlying the proposal, further measures are needed in the road transport sector, in particular as regards Heavy-Duty Vehicles.

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<sup>35</sup> COM (2016) 482 final

<sup>36</sup> Proposal for a Directive of the European Parliament and of the Council amending Directive 2012/27/EU on energy efficiency, COM(2016) 761 final – In this, the Commission proposed an energy efficiency target of 30% for 2030.

<sup>37</sup> COM(2016) 501 final

<sup>38</sup> COM(2017) 283 final

<sup>39</sup> COM(2017) 676 final

<sup>40</sup> SWD(2017) 650 final



## 6.2 Overview of broader EU mobility policies relevant for HDVs

There are a number of different pieces of EU legislation, which are relevant for the decarbonisation of the road transport sector, including heavy-duty vehicles. These are divided into regulatory and non-regulatory measures and are listed below.

### *Regulatory measures*

- The **EU type-approval system** provides a common legal framework for the approval of motor vehicles and their trailers and of systems, components and separate technical units intended for these vehicles. Type approval is compulsory for all categories of whole vehicles, including those built in several stages. For HDVs, the recently adopted **HDV certification legislation** sets out the procedures for certifying CO<sub>2</sub> emissions and fuel consumption through VECTO. The data will be monitored and reported to the Commission as of 2020.
- The "**Eurovignette**" **Directive**<sup>41</sup> aims at internalising negative externalities caused by the road freight transport, such as CO<sub>2</sub> emissions, congestion, noise etc. The 2017 Commission proposal for its revision<sup>42</sup> introduces variations in the infrastructure charges depending on the CO<sub>2</sub> emissions of HDVs as of 1 January 2022. According to the accompanying Impact Assessment<sup>43</sup>, the proposed changes have the potential to reduce CO<sub>2</sub> emissions for road transport by approximately 0.7% for the period 2005 – 2030.
- **Directive on maximum authorized weights and dimensions**<sup>44</sup> requires HDVs in the EU to comply with certain rules on weights and dimensions for road safety reasons and to avoid damaging roads, bridges and tunnels. It also aims at improving the fuel efficiency of HDVs by allowing appropriate vehicle design. Under this legislation, HDVs may exceed the maximum dimensions permitted provided there are improvements in energy efficiency, aerodynamic and safety performance. Implementing legislation is being prepared to enable this provision.
- The **Clean Vehicles Directive**<sup>45</sup> requires public procurers to consider fuel consumption, CO<sub>2</sub>, and pollutant emissions when purchasing road transport vehicles, including HDVs. The Commission has proposed a revision of this Directive in order to better support achieving EU policy objectives on climate change and air pollution and to stimulate the market for clean vehicles and increase competitiveness. Targets are proposed for public procurements of clean vehicles, both LDVs and HDVs, to be implemented as of 2025. For HDVs, the proposed definition of a "clean vehicle" refers to the use of alternative fuels and, for the future, to the CO<sub>2</sub> standards to be established at EU level. The proposal for a revised Clean Vehicle Directive is expected to result in about 1,800 ktonnes CO<sub>2</sub> emission reductions for road transport, which is equivalent to CO<sub>2</sub> reductions of approximately 0.2 % for the period 2005 – 2030.<sup>46</sup>

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<sup>41</sup> Directive 2011/76/EU

<sup>42</sup> COM (2017)275

<sup>43</sup> SWD(2017) 180 final

<sup>44</sup> Directive 2015/719/EU

<sup>45</sup> Directive 2009/33/EC

<sup>46</sup> SWD(2017) 366 final, Part 1/4

- The **Renewable Energy Directive (RED)** contributes to achieving CO<sub>2</sub> savings in road transport by requiring the use of renewable fuels. It sets a target for each Member State of a 10% share of renewable energy in transport by 2020. The 2016 Commission proposal for a revision of the RED<sup>47</sup> reaffirms the importance of renewable energy in the transport sector, aiming by mandating fuel suppliers to provide 6.8% in 2030 of non-food based and advanced low-emission fuels, including renewables. It has been estimated that the changes proposed to the RED have the potential to deliver overall GHG savings in the range of 0.8% - 1.56%<sup>48</sup> in the period 2020 – 2030.
- The **Fuel Quality Directive (FQD)**<sup>49</sup> addresses the provision of common standards and consumer information on cleaner fuels and vehicles. It requires fuel suppliers to reduce the GHG intensity of fuels supplied in 2020 by 6% compared to 2010. This requirement acts as an incentive to promote low-carbon fuels in both light duty and heavy-duty vehicles sectors. It is not intended, though, to keep the GHG provisions of this Directive after 2020 in view of the revision of the RED.
- The **Energy Efficiency Directive (EED)**<sup>50</sup> establishes a set of measures to help the EU reach its 20% energy efficiency target for the whole energy system, including transport. The EED is currently under revision for setting provisions with regards to the period 2021- 2030.
- The **Directive on the deployment of alternative fuels infrastructure (AFID)**<sup>51</sup> aims at promoting the roll-out of alternative fuel infrastructure, which will contribute to the decarbonisation of the EU transport sector and will increase the EU's overall energy security by reducing the transport sector dependence on imported fuel. In 2016 Member States presented their national plans for roll-out of alternative fuels infrastructure until 2030. As indicated in the Action Plan, adopted as part of the November 2017 Clean Mobility Package, the Commission will support their implementation with an additional EUR 860 million in the next few years.
- **The Energy Taxation Directive** establishes the minimum excise duty rates that Member States must apply to energy products for fuel and transport, and electricity. The actual levels of taxation applied are decided by Member States and could vary considerably from one Member State to another. For example the excise duty for diesel ranges between EUR 0.33/l and EUR 0.67/l, which are rather modest levels with limited impact on fuel sales<sup>52</sup>.
- **Tyre labelling:** tyres sold in the EU are subject to energy labelling requirements.<sup>53</sup> Tyre labels aims at supporting consumers in the purchasing decisions for more fuel efficient, better wet braking and less noisy tyres.

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<sup>47</sup> COM/2016/0767 final

<sup>48</sup> SWD(2016) 418 final, Part 1/4

<sup>49</sup> Directive 2009/30/EC

<sup>50</sup> Directive 2012/27/EU

<sup>51</sup> Directive 2014/94/EU

<sup>52</sup> Data for 2016. Source: Road fuel excise duties in the EU provided by EEA, <https://www.eea.europa.eu/data-and-maps/indicators/fuel-prices-and-taxes/assessment-7>

<sup>53</sup> Regulation (EC) No 1222/2009

*Non-regulatory measures*

- The Commission’s **Coach Services Action** aims at further developing of domestic bus and coach services.
- **Horizon 2020** EU Research and Innovation program, aimed at securing Europe's global competitiveness, allocates EUR 6.4 billion to research and innovation initiatives in the transport sector.
- Shift2Rail is the first European rail initiative to seek focused research and innovation (R&I) and market-driven solutions by accelerating the integration of new and advanced technologies into innovative rail product solutions. This initiative is undertaken within the framework of Horizon 2020. It supports the development of a Single European Rail Area (SERA) for a better interoperability of train services in Europe.
- **Green freight programs**, incentivising the sharing of industry best practices. Some of these programs receive financing under the European Structural and Investment Funds, whose transport-related envelope totals EUR 70 billion. That includes EUR 39 billion for supporting the move towards low-emission mobility.<sup>54</sup>

**6.3 Link with problem drivers**

Table 5 provides an assessment of how the EU policies could address the problem drivers identified.

**Table 5: Existing and revised EU policies and problem drivers identified**

Policy Instrument	Driver 1 Road freight transport activity is increasing	Driver 2 Market barriers hindering the uptake of more fuel-efficient technologies	Driver 3 Limited use of zero and low-emission vehicles in the road freight sector
CO2 emissions standards	○	✓✓✓	✓✓
Type approval (Certification)	○	✓	○
Eurovignette Directive	○	✓	✓
Directive on weights and dimensions	✓	✓	○
Clean Vehicles Directive	○	✓	✓✓
Renewable Energy Directive	○	○	✓
Fuel Quality Directive	○	○	○
Energy Efficiency Directive	✓	○	○
AFID	○	○	✓✓
Energy Taxation Directive	✓	✓	○
Tyres Labelling	○	✓	○
Coach Services Action	✓	○	○
Horizon 2020	○	✓	✓
Green freight programmes	○	✓	○

<sup>54</sup> COM (2016) 501 final

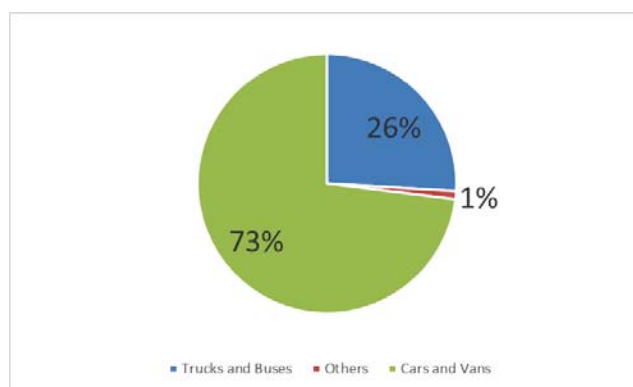
○	No significant impact
✓	Weakly positive
✓✓	Positive
✓✓✓	Strongly positive

## 7 ANNEX 7: PROBLEMS AND DRIVERS – COMPLEMENTARY INFORMATION

### 7.1 Problem 1: HDV sector is a significant and growing source of GHG emissions

In 2015, CO<sub>2</sub> emissions from HDVs represented around 6% of total EU emissions, almost a fifth of all transport emissions and, as shown in Figure 4: Share of HDV and LDV in total road transport CO<sub>2</sub> emissions, slightly more than a quarter of road transport emissions.

**Figure 4: Share of HDV and LDV in total road transport CO<sub>2</sub> emissions**



Source: GHG Inventory data – European Environment Agency<sup>55</sup>

As Figure 5 shows, GHG emissions from HDVs in 2015 were around 19% higher than in 1990, despite some decrease taking place after 2007. Without further action and HDV activity steadily increasing, HDV CO<sub>2</sub> emissions are set to increase by up to 6% between 2015 and 2030<sup>56</sup> and thus to represent an increasing share of road transport emissions, from around 25% in 2015 to around 35% in 2050.

At the same time, as explained in Chapter 1 of the Impact Assessment, the EU has set ambitious targets for reducing GHG emissions by 2030, including for the non-ETS sectors, to which the transport sector must contribute. Cars and vans are already delivering their share and legislation has been proposed<sup>57</sup> so that they continue doing so after 2020.

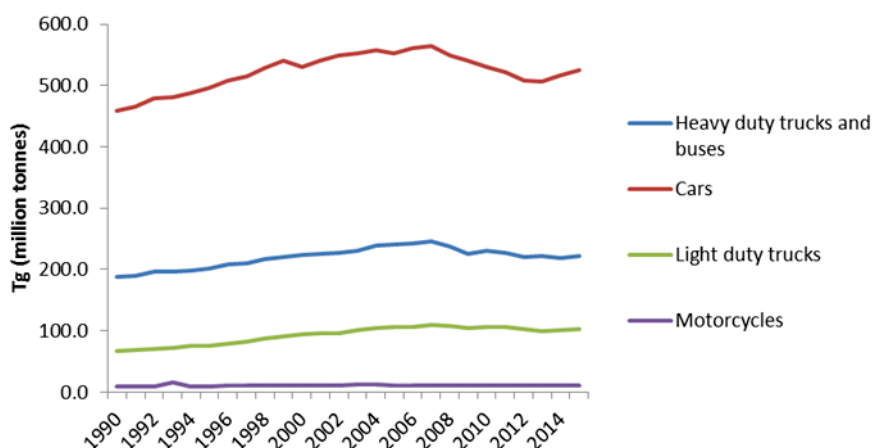
The EU also has a long-term goal of reducing GHG emissions by 80-95% by 2050 compared to 1990 levels as its contribution to global efforts required to meet the Paris Agreement commitments. All sectors will have to play their part if this level of ambition is to be achieved and if the costs and severe impacts of climate change are to be avoided.

<sup>55</sup> GHG Inventory data 2016, <http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer>

<sup>56</sup> SWD(2017) 180 final

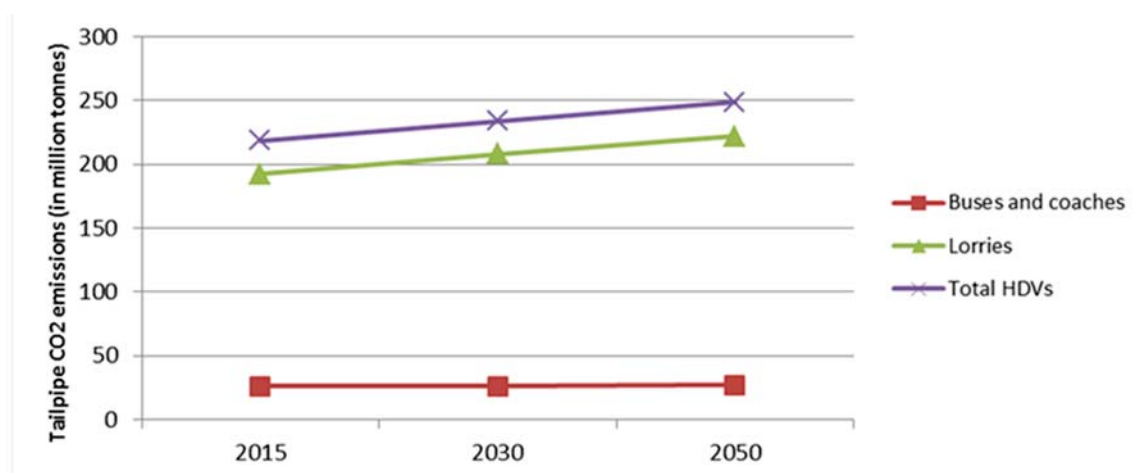
<sup>57</sup> COM(2017) 676 final

**Figure 5: Road Transport GHG emissions 1990 – 2015**



Source: GHG Inventory data – European Environment Agency<sup>58</sup>

**Figure 6: Projected HDV CO<sub>2</sub> emissions 2015-2050**



Source: Primes-Tremove

### 7.2 Problem 3: EU HDV manufacturers and component suppliers are at risk of losing their technological and innovation leadership position

The EU HDV manufacturers and component suppliers currently have a global technological leadership position, as EU lorries are more fuel efficient than lorries in other economies. Table 6 shows that new lorries in the EU for medium and heavy freight transport have lower average fuel consumption than lorries in other regions of the world.

<sup>58</sup> GHG Inventory data 2016, <http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer>

**Table 6: Typical average fuel consumption of new lorries at representative payloads, by lorry category in selected countries (litres of diesel equivalent/100 km)**

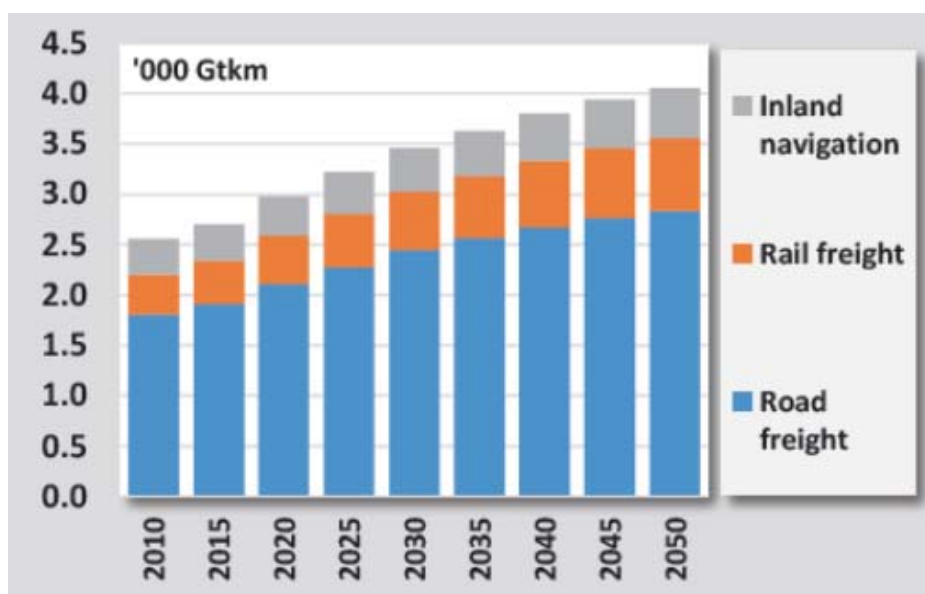
Country	Light commercial vehicles			Medium-freight truck			Heavy-freight trucks		
	Ide/ 100km	payload (tonnes)	Ide/ 100tkm	Ide/ 100km	payload (tonnes)	Ide/ 100tkm	Ide/ 100km	payload (tonnes)	Ide/ 100tkm
United States	7.9	0.55	14.4	28.2	6.4	4.4	41.2	15.4	2.7
European Union	6.8	0.62	11	23.3	7	3.3	34.6	14.5	2.4
China	9.9	0.82	12.1	23.3	8.7	2.7	39.1	13.3	2.9
India	6.4	0.96	6.7	25	9.7	2.6	44.9	12.9	3.5

Source: IEA, *The future of trucks* (2017)

### 7.3 Driver 1: Road freight transport activity is increasing

In the longer term, under current trends and adopted policies<sup>59</sup>, road freight transport activity is set to increase between 2010 and 2050 by about 56% (1.1% p.a.) due to a strong correlation with economic growth (see Figure 7 below).

**Figure 7: Evolution of freight transport activity by mode**



Source: *EU Reference Scenario 2016*

<sup>59</sup> SWD(2017) 180 final

#### 7.4 Driver 3: Limited use of zero- and low-emission vehicles in the HDV sector

As shown in Table 7, almost all traditional manufacturers have announced plans for electrification, even if the potential sales volume would remain small in view of the current high upfront costs.

**Table 7: List of manufacturers' and suppliers' announcements on zero- and low emission HDV<sup>60</sup>**

<b>Manufacturer or supplier</b>	<b>Announcement</b>
<b>Daimler</b>	Fully electric-powered light lorry
<b>Volvo/Renault</b>	All-electric lorries in 2019
<b>Iveco</b>	Presented a long-haul concept lorry in 2016
<b>Man</b>	eTruck (18 to 36 tons for distribution purposes) is currently undergoing tests
<b>Scania</b>	To develop and commercialise battery cell technology for heavy commercial vehicles with batteries producer Northvolt
<b>Nikola Motor</b>	ZEV lorries by end 2019
<b>Cummins</b>	All-electric powertrain for buses and delivery vehicles by 2019
<b>BYD</b>	EU market: launch of 7.5 tons electric lorry planned in July 2018 in view of market availability in 2019  Chinese market: broader range of electric lorries available on the market, including larger lorries, construction and garbage vehicles
<b>Tesla</b>	Announced an electric lorry. Date of actual release not yet known

<sup>60</sup>Sources :<http://media.daimler.com/marsMediaSite/en/instance/ko/Daimler-Trucks-launches-E-FUSO-and-all-electric-heavy-duty-truck-Vision-One.xhtml?oid=30010405>  
<http://corporate.renault-trucks.com/en/press-releases/2015-02-23-the-french-poste-office-and-renault-trucks-jointly-test-a-hydrogen-powered-truck-running-on-a-fuel-cell.html>  
<https://www.iveco.com/Corporate-en/Company/Pages/Electric-vehicles.aspx>  
[https://www.volkswagenag.com/en/news/2017/02/man\\_etruck.html](https://www.volkswagenag.com/en/news/2017/02/man_etruck.html)  
<https://www.scania.com/group/en/electric-trucks-how-the-technology-works/>  
<https://electrek.co/guides/tesla-semi/>  
<http://www.byd.com/>  
<https://www.cummins.com/news/2017/08/29/5-cool-things-about-our-electric-powertrain-concept-truck>  
<https://nikolamotor.com/motor>

## 8 ANNEX 8: STEP-WISE APPROACH FOR REGULATING HDV CO<sub>2</sub> EMISSIONS: VECTO, CERTIFICATION AND MONITORING/REPORTING OF HDV CO<sub>2</sub> EMISSIONS.

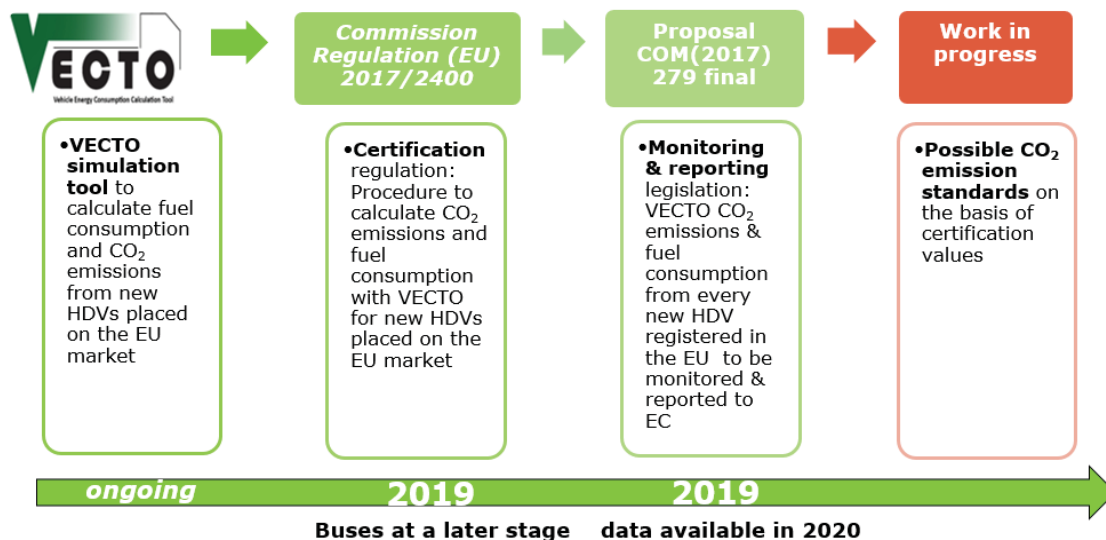
The first initiative to tackle HDV GHG emissions in the EU was a strategy adopted in 2014.<sup>61</sup> This strategy focused on short-term action to certify, monitor and report HDV CO<sub>2</sub> emissions, which is an essential first step towards reducing them. These actions were confirmed by the 2016 *Low-emission mobility strategy* and the Commission has adopted the following legislation in the course of 2017 to implement them:

- A Commission Regulation on the determination of carbon dioxide emissions and fuel consumption of HDVs<sup>62</sup> (the so-called "Certification Regulation"), which was adopted on 12 December 2017.
- A proposal<sup>63</sup> for a Regulation on the monitoring and reporting of CO<sub>2</sub> emission and fuel consumption data, which is currently being discussed by the European Parliament and the Council.

The Certification Regulation requires HDV manufacturers, as of 1 January 2019, to determine the CO<sub>2</sub> emissions and fuel consumption of new vehicles they place on the EU market. The CO<sub>2</sub> emissions are calculated by using the Vehicle Energy Consumption Calculation Tool (VECTO), which is a simulation tool developed for that purpose by the Commission. Information on the CO<sub>2</sub> emissions and fuel consumption of new HDVs will be declared for the registration of vehicles under the EU type-approval legislative framework. The Monitoring and Reporting Regulation requires that these data are monitored and reported to the Commission, and will be made publicly available.

The step-wise approach on the regulation of HDV CO<sub>2</sub> emissions is summarized in Figure 8 below. More information on the simulation tool VECTO, on the certification procedure and on the monitoring and reporting system is given in Sections 8.1 to 8.3 below.

**Figure 8: Step-wise approach for regulating HDV CO<sub>2</sub> emissions**



<sup>61</sup> COM(2014) 285 final

<sup>62</sup> Commission Regulation (EU) 2017/2400

<sup>63</sup> COM(2017) 0279 final



## 8.1 VECTO

### 8.1.1 Introduction

The Commission has since 2009 engaged with main industry stakeholders in the development of a simulation tool for whole vehicles CO<sub>2</sub> emissions and fuel consumption that should be applicable to all main categories of HDVs.

In the project “Reduction and testing of Greenhouse Gas Emissions from Heavy duty vehicles”<sup>64</sup> a simulation based test procedure where the relevant components of the HDV were tested and based on this data a simulation tool calculating the fuel consumption and the CO<sub>2</sub> emissions in vehicle class specific test cycles was chosen as the method that delivers robust results of CO<sub>2</sub> figures for HDVs and appears manageable for the manufacturers and public administrations that have to deal with the test procedure.

The relevant data for the simulation of HDV CO<sub>2</sub> that have been identified include the engine fuel efficiency map, vehicle weight, tires rolling resistance coefficients (RRC), aerodynamic drag coefficient multiplied by the frontal area (A) of the vehicle (C<sub>d</sub>xA), moments of inertia from the vehicle including standardised bodies or trailers, the specifications of the gear boxes and efficiency of the auxiliaries.

Such a simulation based approach should allow cost efficient testing of multiple HDV variations by compiling the measured component data in the simulator. This approach also makes it possible to easily assess the CO<sub>2</sub> emissions impact of improved trailer and body structure design. The proposed test procedure has been applied experimentally on four HDV categories so far and appears to give reliable and accurate results.

The simulation-based method consists of:

- On-road measurement of driving resistances
- Determination of drivetrain losses
- Determination of power demand of engine auxiliaries and other consumers
- Measurement of the engine fuel consumption map as extension to the engine's type approval tests
- Simulation of the fuel consumption and the resulting CO<sub>2</sub>-emissions from the vehicle using the aforementioned input data for predefined representative driving cycles.

The single steps described in brief are as follows:

The driving resistances of the vehicle will be measured during constant speed on a test track. Standardized bodies and trailers will be used to obtain reliable air resistance values. For reproducible results, corrections for influences of road gradient, wind speed, ambient temperature and air pressure as well as for velocity unsteadiness, have to be applied to the measured driving resistance values.

For the body and trailer manufacturers an option for a less extensive procedure can be applied. Improved bodies or trailers (aerodynamics, curb weight) can be tested in comparison to the standard components via constant speed tests. The relative change against the standard body or trailer can then be introduced into the simulation tool to

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<sup>64</sup> [https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/hdv\\_2011\\_01\\_09\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/hdv_2011_01_09_en.pdf)

calculate the fuel consumption and the CO<sub>2</sub> emissions of the alternative vehicle and body-configuration.

Drivetrain friction losses and the power demand of engine auxiliaries like engine fan, air compressor or heating ventilation and air conditioning system (HVAC), will be defined as default values. If manufacturers use more efficient components, the default values can be replaced by component specific efficiency maps.

Since several technical options to improve the fuel efficiency of HDV have different reduction potentials at varying driving conditions, the definition of representative driving cycles is important for a realistic ranking of the specific fuel consumption. Driving cycles (or mission profiles) for the different categories and usage of HDVs are newly developed to give more realistic results on fuel consumption.

It is desirable for the methodology to address all characteristics that are relevant to the efficiency of the entire vehicle. Realistic values for the fuel efficiency of various HDV in different mission profiles will improve customer information and incentivise manufacturers to develop and apply fuel saving technologies. In future a standardised test procedure could support other measures in the HDV sector including CO<sub>2</sub> emissions monitoring, labelling or programmes for HDV customers to calculate HDV fuel efficiency.

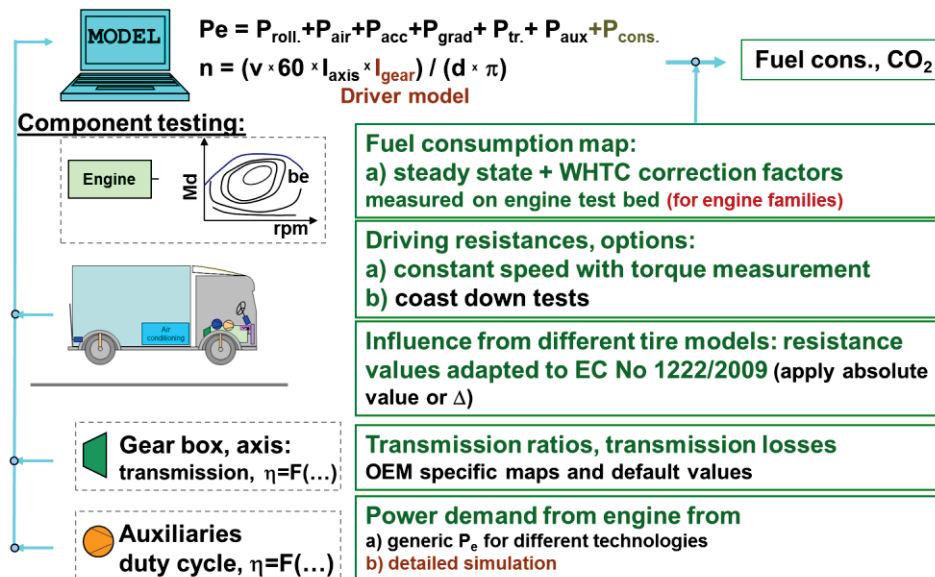
The main targets for the test procedure are:

- Repeatable (within same laboratory) and reproducible (between different laboratories)
- Incentive to apply efficient technologies and to optimise the entire vehicle set-up
- High sensitivity for fuel saving measures
- Reasonable costs and efforts to run and examine the procedure
- Simple and robust

#### *8.1.2 Schematic overview of simulation model and computational programme*

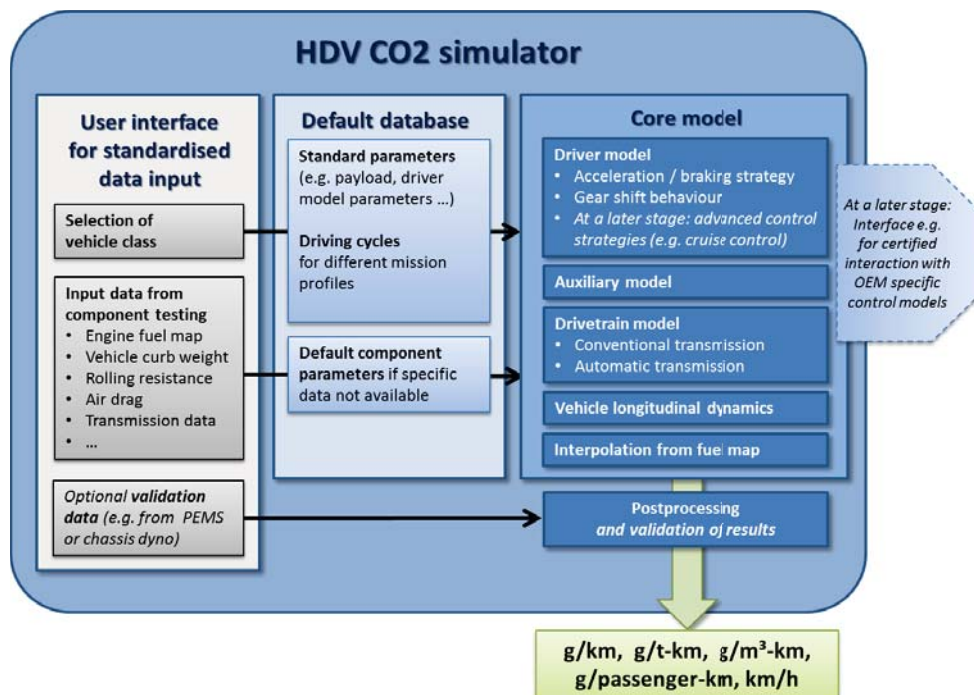
Figure 9 gives an overview of the test procedure. Rolling resistance, air resistance, power to accelerate translational and rotatory moved masses, power resulting from road gradients, losses in the transmission system and power demand from auxiliaries are considered in the simulation.

Figure 9: Schematic picture of the test procedure



All the measured data of the components / subsystems of a HDV will then be used as input data in a HDV energy/CO<sub>2</sub> simulation tool. The structure of the simulation tool is shown in Figure 10.

Figure 10: Structure of the simulation tool



The simulation tool will calculate the energy consumption of the whole HDV and give as a result the fuel consumption or CO<sub>2</sub> emissions in g/km, g/tkm, g/m<sup>3</sup>km or g/passenger.km (for buses).

### 8.1.3 Adequacy of VECTO as a simulation tool

In order to evaluate the adequacy of the VECTO simulation tool, the Commission carried out a study aimed at assessing to what extent the effect of relevant technologies on CO<sub>2</sub> emissions is properly captured by VECTO. The study was performed by JRC in 2016<sup>65</sup>. A number of stakeholders, including HDVs manufacturers and suppliers were consulted.

The study concludes that “... a large part of the technologies under investigation were already sufficiently captured by VECTO tool and the certification methodology.” and that “... VECTO has achieved ...a good level of maturity”

The study also identified some new technologies that are likely to enter into the market in the next couple of years will require additional work to further develop VECTO with software developments.

Such new technologies include Advanced Driver Assist Systems (ADAS), Platooning, Waste Heat Recovery (WHR), hybrids, Electric turbocharger, Air Conditioning efficiency and refrigerant, Active flow systems, Trailer aerodynamic improvements, Dual Clutch Transmission and Neutral idle.

Most of the above mentioned technologies have been already considered in the future development plan of VECTO and will be addressed soon. Additional and detailed technical input from the stakeholders will be required as most of those technologies have not entered into the market yet.

Figure 11 presents an overview of the degree by which VECTO captures the different technology categories in 2016. These categories includes:

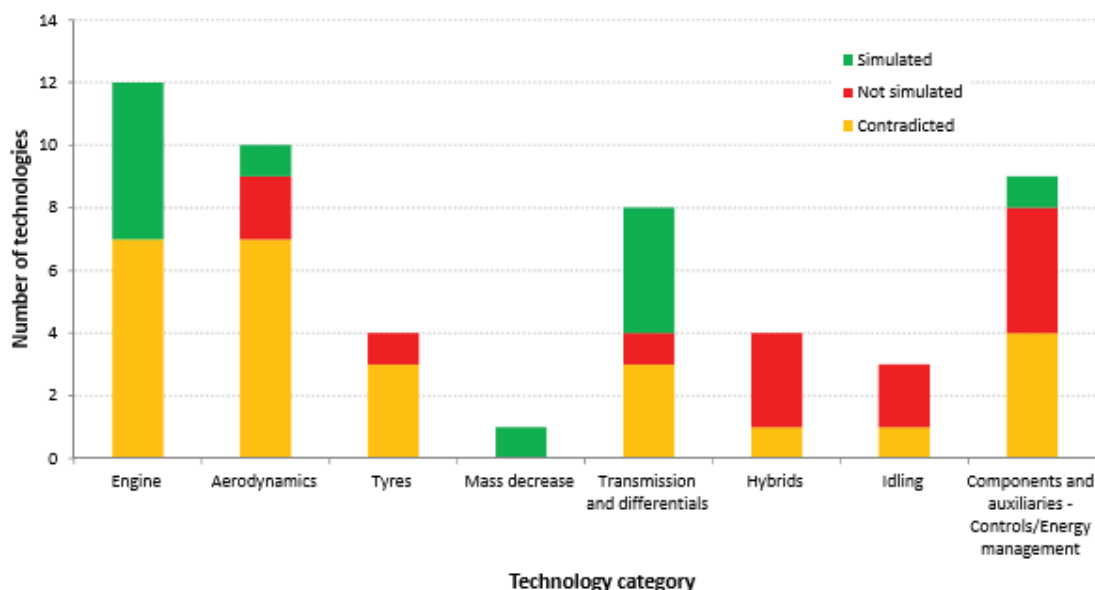
- existing technologies which are already simulated accurately as indicated above
- new technologies for which further development in VECTO is required

Further information on the development plans of VECTO is provided in the next section.

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<sup>65</sup> Report on VECTO Technology Simulation Capabilities and Future Outlook, JRC, 2016

**Figure 11: Results of survey – views of respondents on level of simulation of different existing and new technologies in VECTO (2016)**<sup>66</sup>



- **Simulated:** All respondents replied that the effect of the technology is sufficiently captured.
- **Not simulated:** All respondents replied that the effect of the technology is not sufficiently captured.
- **Contradicted:** Some respondents replied that the effect of the technology was sufficiently captured, while some others replied that it is not.

#### 8.1.4 Future development steps of the VECTO tool

At this stage, VECTO can simulate only lorries above 7.5 tonnes.

The VECTO tool will have to be extended to other categories of HDVs (e.g. city and inter-city buses, municipal utility lorries, service and urban delivery lorries, construction lorries). Moreover, a platform or dedicated webpage that VECTO will be hosted has to be created.

The next phase of development of the VECTO tool, which will take place in the period 2020 - 2021 is thus expected to include:

- the further development and finalisation of VECTO to cover other categories of HDVs such as city-buses, coaches and small lorries – planned implementation 2020
- a dedicated webpage where the tool will be hosted; VECTO will be a downloadable executable file that will be uploaded on this page and will be available for all public users (universities, research institutes, independents etc.). A detailed and regularly updated FAQ doc will be also uploaded on the same webpage for reference use;

<sup>66</sup> Report on VECTO Technology Simulation Capabilities and Future Outlook, JRC, 2016

- certain types of drivetrains (i.e. Hybrids) will be included in VECTO in 2021;
- specific modern technologies, identified by the 2016 JRC study as “not-simulated” in VECTO, such as Advanced Driver Assist Systems (ADAS), Waste Heat Recovery (WHR), Eco-features, gear shifting strategy etc. will be addressed in VECTO by 2020;
- new gear shift strategies for various types of transmissions and mission profiles for M2 and N2 vehicles will be also elaborated;
- review of updates cycles and implementation into VECTO for "Urban delivery" and "Construction" cycles;  
 applications where both diesel and gas are used as fuels at the same time in different relative shares (dual-fuelled engines) will be taken into account in VECTO;
- update continuously the tyre dimensions table within the tool so any dimensions sold in the future is covered by the list;
- and the adaptation of the required documentation of the certification/registration process for all relevant categories of vehicles.

## 8.2 Certification Regulation

By allowing the calculation of the CO<sub>2</sub> emissions and fuel consumption of heavy-duty vehicles in a comparable way, VECTO has laid the ground for a certification methodology for those parameters, as part of the type approval of new heavy-duty vehicles before they are placed on the EU market. This methodology is used instead of the testing on a chassis dynamometer carried out for light-duty vehicles as such an approach is not possible for HDVs due to the numerous types and configurations of vehicles.

According to the new Certification Regulation<sup>67</sup>, which is an implementing act of the existing type approval legislation<sup>68</sup>, each heavy-duty vehicle within the groups covered that is to be placed on the EU market, will need to be simulated with VECTO in order to determine of its CO<sub>2</sub> emissions and fuel consumption. Vehicle manufacturers themselves will perform the simulation on the basis of certified input data of all different vehicle components and of a certified process of sourcing, managing and applying such input data.

For the purpose of the Certification Regulation, lorries have been divided into 18 vehicle groups (groups 0 to 17)<sup>69</sup> depending on their axle configuration (4x2, 6x2, 8x2 etc.)<sup>70</sup>, chassis configuration (rigid or tractor) and technically permissible maximum laden mass, also called gross vehicle weight (GVW).<sup>71</sup>

<sup>67</sup> [Commission Regulation \(EU\) 2017/2400](#)

<sup>68</sup> Directive [2007/46/EC](#)

<sup>69</sup> See Annex I to [Commission Regulation \(EU\) 2017/2400](#)

<sup>70</sup> A "4x2" axle configuration means that the HDV has a two-drive axles with four wheels (similarly for the other configurations).

<sup>71</sup> GVW is the weight of the fully loaded vehicle and / or trailer, including all cargo, fluids, passengers, and optional equipment.

The 18 vehicle groups are attributed five different mission profiles according to their specific use – Long Haul, Regional Delivery, Urban Delivery, Municipal Utility and Construction.

The Certification Regulation applies to:

- vehicles in the groups 4, 5, 9 and 10, as from 1 July 2019;
- vehicles in the groups 1, 2, and 3, as from 1 January 2020;
- vehicles in the groups 11, 12 and 16, as from 1 July 2020.




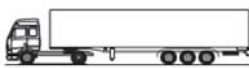




The Certification Regulation will later be extended to cover the remaining lorry groups, as well as buses and coaches, and trailers, once VECTO is ready to simulate these vehicles.

**Table 8** presents a summarized list of the 18 vehicle groups, while Table 9 provides a visual illustration of the vehicles in the groups 4, 5, 9 and 10, both without and with trailers.

**Table 8: Overview of certification vehicle groups**

Vehicle group	Axle configuration	Chassis configuration	Technically permissible maximum laden mass (tons)
0	4x2	Rigid	>3.5 – <7.5
1	4x2	Rigid (or tractor)	7.5 – 10
2	4x2	Rigid (or tractor)	>10 – 12
3	4x2	Rigid (or tractor)	>12 – 16
4	4x2	Rigid	>16
5	4x2	Tractor	>16
6	4x4	Rigid	7.5 – 16
7	4x4	Rigid	>16
8	4x4	Tractor	>16
9	6x2	Rigid	all weights
10	6x2	Tractor	all weights
11	6x4	Rigid	all weights
12	6x4	Tractor	all weights
13	6x6	Rigid	all weights
14	6x6	Tractor	all weights
15	8x2	Rigid	all weights
16	8x4	Rigid	all weights
17	8x6 or 8x8	Rigid	all weights

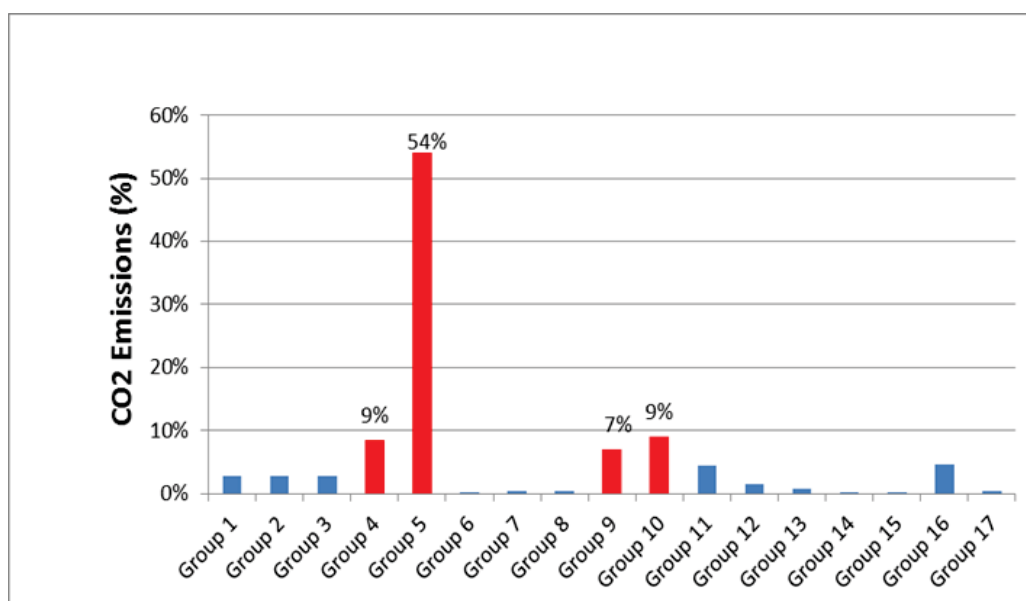
**Table 9: Visual illustration of HDVs in groups 4, 5, 9 and 10**

Vehicle group	Axle and chassis configuration	Without trailer	With trailer
4	4x2 Rigid		
5	4x2 Tractor		
9	6x2 Rigid		
10	6x2 Tractor		

As shown in Figure 12, based on calculations made in 2012<sup>72</sup>, lorries falling in Groups 4, 5, 9 and 10 are together responsible for some 79% of the overall CO<sub>2</sub> emissions of the 18 vehicle groups listed above and about 65% to 70% of total HDV CO<sub>2</sub> emissions. Buses and coaches represent about 10% of the total HDV CO<sub>2</sub> emissions. Annually, some 250,000 new lorries falling into these four groups are registered.

The lorries in group 5 (4x2 tractor with a GVW of more than 16 t) contribute by far the most to the total emissions, accounting for some 54% of the total emissions of the 18 HDV groups shown.

**Figure 12: Estimated share of total CO<sub>2</sub> emissions from different HDV (lorry) groups**



Source: TU Graz et al, 2012

<sup>72</sup> TU Graz, TNO, TÜV Nord, VVT, AVL, LAT and Heinz Steven (2012), *Reduction and Testing of Greenhouse Gas Emissions from Heavy Duty Vehicles - LOT 2: Development and testing of a certification procedure for CO<sub>2</sub> emissions and fuel consumption of HDV*, [https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/hdv\\_2011\\_01\\_09\\_en.pdf](https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/heavy/docs/hdv_2011_01_09_en.pdf)



In view of the high share of total CO<sub>2</sub> emissions of HDV groups 4, 5, 9 and 10, these groups were selected as the first vehicles to be covered by VECTO and to which the Certification Regulation will apply.

In order to ensure that the fuel and CO<sub>2</sub> values declared by the vehicle manufacturer accurately reflect the actual values, provisions for verifying such conformity have been introduced in the certification procedure, so-called conformity of production provisions. These tests apply to both vehicle and components manufacturers. The verification test for the whole vehicle is currently being developed, whereas the tests for component manufacturers are already defined in the Regulation.

Once, the vehicle manufacturer has uploaded, according to the certification procedure, the characteristics of the vehicle and the certified input data from the different components into the VECTO simulation tool at the end of the production line, the outcome of the simulation will be a set of files containing a list of parameters, so-called output data.

In particular the VECTO simulation tool will produce two files: the manufacturer's record file and the customer information file. The manufacturer's record file includes information on the CO<sub>2</sub> emission and fuel consumption of the vehicle for the different mission profiles, loads and fuel combination that are specific to the vehicle as declared by the vehicle manufacturer.

The customer information file is a summary of the most relevant parameters for the buyer of the vehicle, including the CO<sub>2</sub> emission and fuel consumption values, in order to provide more transparency on the performance of the vehicle, which currently is lacking in the HDV market.

### **8.3 Monitoring and reporting**

Under the proposed Regulation on monitoring and reporting of CO<sub>2</sub> emissions data from HDV, the Commission will collect the CO<sub>2</sub> emissions and fuel consumption data resulting from the certification procedure.

The data will be made publicly available by the European Environment Agency (EEA) on behalf of the Commission, starting in 2020 to cover data monitored in 2019. This will increase transparency in the HDV market.

The monitoring data include a subset of the manufacturer's record file provided by VECTO under the certification procedure, and in particular the CO<sub>2</sub> emissions, fuel consumption and other relevant technical parameters.

The EEA will combine the registration data from national authorities with the monitoring data from manufacturers and publish annual monitoring data for each new vehicle registered in the EU that was subject to the certification procedure. For those HDVs not yet covered by the certification, and for which therefore no monitoring data is available yet, the EEA will publish the registration data provided by national authorities.

## 9 ANNEX 9 – DESCRIPTION OF THE OPTIONS - COMPLEMENTARY INFORMATION

### 9.1 Policy option categories

The options considered in the Impact Assessment cover a number of elements, which are grouped into five categories: (i) CO<sub>2</sub> emission targets; (ii) Distribution of target across vehicle groups and manufacturers; (iii) Incentives for zero- and low-emission vehicles; (iv) Elements for cost-effective implementation and (v) Governance.

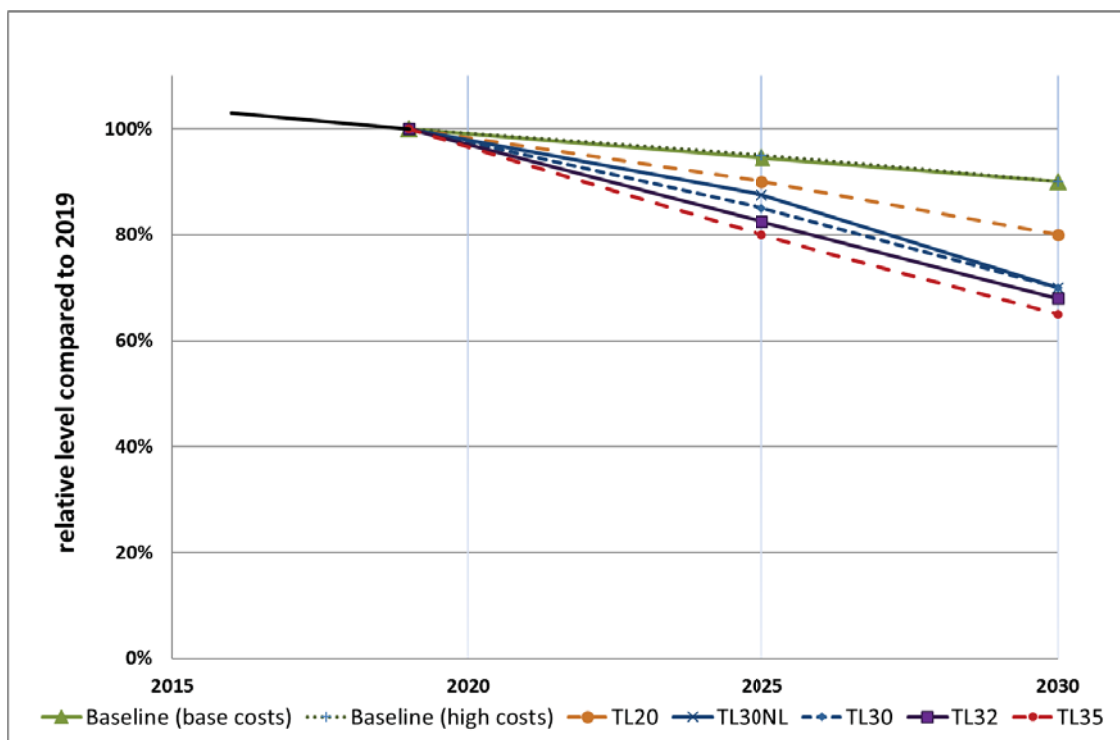
Table 10 shows how these categories are related to the problems outlined in Section 4 of the Impact Assessment.

**Table 10: Policy options and problems**

Key Policy Areas	Problem 1: HDV sector source of growing emissions	Problem 2: Transport operators missing out on fuel savings	Problem 3: HDV sector risks to loose technological leadership
CO <sub>2</sub> emission targets	✓	✓	✓
Distribution of target across vehicle groups and manufacturers		✓	✓
Incentives for zero- and low-emission vehicles	✓		✓
Elements for cost-effective implementation		✓	✓
Governance	✓	✓	

## 9.2 Target levels – baseline and overview of options

Figure 13: EU fleet-wide CO<sub>2</sub> emission target level trajectories under different policy options and emission reductions expected under the baseline



### 9.3 Incentives for Zero- and Low-Emission Vehicles (ZEV/LEV)- context

The July 2016 Commission's European Strategy for Low-Emission mobility<sup>73</sup> highlighted the increasing role of zero- and low-emission vehicles in delivering CO<sub>2</sub> reductions in the road transport sector, especially in the medium- and long-term.

For the Impact Assessment, two main types of vehicles will be considered:

1. **Zero-emission vehicles (ZEV):** vehicles having no CO<sub>2</sub> tailpipe emissions during operation – these are either fully electric or hydrogen-fuelled vehicles;
2. **Low-emission vehicles (LEV):** vehicles having tailpipe CO<sub>2</sub> emissions, which are significantly lower than those of "average" conventional vehicles.

While electrification technologies similar to those available for LDV exist for the smaller HDVs, the barriers for their uptake are much bigger for the heavier lorries in groups 4, 5, 9 and 10, which are the main focus of this Impact Assessment. This is because of their greater size and weight and their more rugged operations. For those lorries, the main challenge is finding ways to reduce battery needs. One way of doing so is through electric road systems (ERS) providing electricity along the road using either overhead catenary lines or inductive power transfer.<sup>74</sup> Pilot applications in Germany, Sweden and the United States have begun installing catenary lines along roadways<sup>75</sup>.

Battery and fuel cell electric lorries are currently in the pilot or early deployment stages, mainly amongst the vehicle groups outside the scope of this impact assessment<sup>76</sup>. Some manufacturers have announced plans to develop zero-emission lorries, as illustrated in Annex 7.4. However, only a very limited number of these vehicles are currently being used.

High costs remain one of the main hurdles faced by these lorry technologies. An additional barrier for the uptake of zero- and low-emission vehicles, in addition to the high costs of the vehicle technology, is the current lack of recharging and refuelling infrastructure. This was recently highlighted and addressed in the Commission's Communication establishing an Action Plan on Alternative Fuels Infrastructure.<sup>77</sup>

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<sup>73</sup> <https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-501-EN-F1-1.PDF>

<sup>74</sup> IEA (2017) The Future of Trucks – Implications for Energy and Environment

<sup>75</sup> Siemens (2017), “eHighway: Electrified heavy duty road transport” (<https://www.siemens.com/content/dam/webassetpool/mam/tag-siemens-com/smdb/mobility/road/electromobility/ehighway/documents/ehighway-2017.pdf>) and Akerman, P. presentation at joint IEA and JRC workshop, “The future role of trucks for energy and environment”, 8 November 2016, [http://www.iea.org/media/workshops/2016/thefutureroleoftrucks/7\\_Akerman\\_PA\\_eHighway\\_IEA\\_JRC\\_workshop.pdf](http://www.iea.org/media/workshops/2016/thefutureroleoftrucks/7_Akerman_PA_eHighway_IEA_JRC_workshop.pdf)

<sup>76</sup> IEA (2017) The Future of Trucks – Implications for Energy and Environment

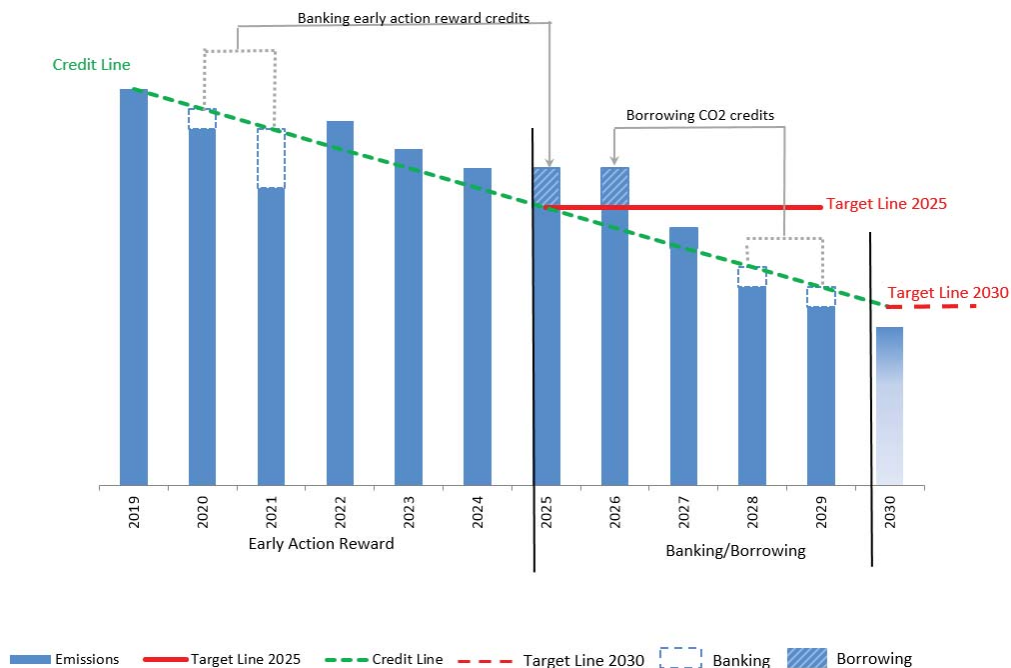
<sup>77</sup> COM(2017)652 final

## 9.4 Banking and borrowing – design elements

Regarding the option of banking and borrowing, parameters should be set to avoid possible abuse and excessive accumulation of credits. Therefore, the following key parameters would be set as part of this option, as illustrated in Figure 14:

- During the **period 2019-2024**, banking would be allowed in order to reward manufacturers for early action. Credits could be gained if emissions are below a linear trajectory between the 2019 emission levels and the 2025 target of the manufacturer. The credits banked during this period could be used in the year 2025 only.
- During the **period 2025-2029**, the linear trajectory for banking is defined by the 2025 and the 2030 CO<sub>2</sub> targets of the manufacturer. In case the 2030 target would be indicative (option Timing 1), the trajectory could be established as part of the review of the legislation in 2022. Credits accumulated could not be carried over to 2030 or beyond.
- In case of exceedance of the emissions target, a manufacturer could choose whether to pay the penalties or to borrow CO<sub>2</sub> credits to be redeemed in subsequent years. Borrowing would be limited to a maximum of 5% of the specific emissions target.

**Figure 14 : Banking and borrowing - illustration of the design elements**



## 10 ANNEX 10: IMPACTS OF POLICY OPTIONS – COMPLEMENTARY INFORMATION

The information in this Annex complements Section 6.2 of the Impact Assessment.

### 10.1 Fleet composition under different target level options

In the PRIMES-TREMOVE model, the uptake of LNG lorries is limited due to some assumptions about the availability of LNG fuel and supply infrastructure. With these limitations on LNG lorries and the cost curves applied, certain emission reduction targets could not be achieved. For the base cost assumptions, this was the case for the 35% reduction target in 2030 and for the high cost assumptions, this occurred for all targets with more than 30% reduction. Therefore, for modelling those options, limitations in PRIMES-TREMOVE were removed allowing further CO<sub>2</sub> emission reductions up to the target level by increasing the LNG share in the fleet.

Table 11 shows the composition of the new lorry fleet in terms of diesel and LNG vehicle share under the baseline and different target level options.

**Table 11: New lorry fleet composition in 2025 and 2030 under the baseline and different target level options, using the base and high cost assumptions, respectively**

Base costs assumptions	2025		2030	
	Diesel	LNG	Diesel	LNG
Baseline	97.6%	2.4%	96.3%	3.7%
TL20	94.0%	6.0%	89.6%	10.4%
TL30NL	91.4%	8.6%	81.9%	18.1%
TL30	90.6%	9.4%	81.3%	18.7%
TL32	89.0%	11.0%	79.6%	20.4%
TL35	87.2%	12.8%	77.5%	22.5%

High costs assumptions	2025		2030	
	Diesel	LNG	Diesel	LNG
Baseline	97.6%	2.4%	96.3%	3.7%
TL20	93.2%	6.8%	88.1%	11.9%
TL30NL	89.6%	10.4%	80.4%	19.6%
TL30	88.9%	11.1%	79.9%	20.1%
TL32	87.7%	12.3%	78.8%	21.2%
TL35	86.9%	13.1%	78.4%	21.6%

## 10.2 Net economic savings over the vehicle lifetime from a societal perspective

**Table 12: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/lorry)**

2025 (EUR/lorry)	Cost assumptions	TL20 (10%)	TL30NL (12.5%)	TL30 (15%)	TL32 (17.5%)	TL35 (20%)
<i>Capital cost [1]</i>	<i>Base</i>	858	1,770	3,088	4,492	7,339
	<i>High</i>	3,077	6,344	10,800	17,720	27,797
<i>Fuel Savings [2]</i>	<i>Base</i>	8,995	18,396	30,613	39,312	51,539
	<i>High</i>	17,418	29,278	39,488	50,175	60,123
<i>Net Savings [2] - [1]</i>	<i>Base</i>	<b>8,137</b>	<b>16,627</b>	<b>27,525</b>	<b>34,820</b>	<b>44,200</b>
	<i>High</i>	<b>14,341</b>	<b>22,934</b>	<b>28,687</b>	<b>32,455</b>	<b>32,326</b>
2030 (EUR/lorry)	Cost assumptions	TL20 (20%)	TL30 *	TL32 (32%)	TL35 (35%)	
<i>Capital cost [1]</i>	<i>Base</i>	4,657	19,291	26,572	33,185	
	<i>High</i>	13,721	47,618	52,073	58,760	
<i>Fuel Savings [2]</i>	<i>Base</i>	39,393	82,363	90,881	102,793	
	<i>High</i>	48,841	91,054	101,198	116,404	
<i>Net Savings [2] - [1]</i>	<i>Base</i>	<b>34,736</b>	<b>63,071</b>	<b>64,308</b>	<b>69,608</b>	
	<i>High</i>	<b>35,120</b>	<b>43,436</b>	<b>49,125</b>	<b>57,644</b>	

\* Results for TL30NL in 2030 are very similar to those for TL30

Table 13 shows the average additional manufacturing costs under the different target level options (i.e. the capital costs shown in Table 12) as a percentage of the purchase price of an average lorry, which is assumed to be around 110,000 EUR. It shows that the relative additional manufacturing costs are quite limited in 2025, in particular under the less ambitious target levels options and when taking the base costs assumptions. However, the average relative costs become high, up to half of the vehicle price at the higher target levels in 2030 and when using the high cost assumptions.

**Table 13: Additional manufacturing costs in 2025 and 2030 (as a percentage of the vehicle purchase price)**

2025 capital cost	Cost assumptions	TL20 (10%)	TL30NL (12.5%)	TL30 (15%)	TL32 (17.5%)	TL35 (20%)
<i>(% of vehicle purchase price)</i>	<i>Base</i>	0.8%	1.6%	2.8%	4.1%	6.7%
	<i>High</i>	2.8%	5.8%	9.8%	16.1%	25.3%
2030 capital cost	Cost assumptions	TL20 (20%)	TL30 *	TL32 (32%)	TL35 (35%)	
<i>(% of vehicle purchase price)</i>	<i>Base</i>	4.2%	17.5%	24.2%	30.2%	
	<i>High</i>	12.5%	43.3%	47.3%	53.4%	

\* Results for TL30NL in 2030 are very similar to those for TL30

### 10.3 Avoided CO<sub>2</sub> costs

Table 14 shows the estimated additional avoided CO<sub>2</sub> costs for lorries in 2025 and 2030 for the different target level options assessed and using the base and high cost assumptions. It shows that these external benefits increase as the CO<sub>2</sub> target gets stricter.

**Table 14: Avoided CO<sub>2</sub> cost over the vehicle lifetime in 2025 and 2030 (EUR/lorry)**

2025 (EUR/lorry)	Cost assumptions	TL20 (10%)	TL30NL (12.5%)	TL30 (15%)	TL32 (17.5%)	TL35 (20%)
Avoided CO <sub>2</sub> costs	Base	1,240	2,626	4,668	6,054	8,169
	High	2,626	4,376	6,127	7,805	9,555
2030 (EUR/lorry)	Cost assumptions	TL20 (20%)	TL30 * (30%)		TL32 (32%)	TL35 (35%)
Avoided CO <sub>2</sub> costs	Base	6,831	14,289		15,820	17,670
	High	8,479	15,624		17,116	19,319

\* Results for TL30NL in 2030 are very similar to those for TL30

### 10.4 TCO-first use (5 years)

**Table 15: Net economic savings from a first use (5 years) perspective in 2025 and 2030 (EUR/lorry)**

2025 (EUR/lorry)	Cost assumptions	TL20 (10%)	TL30NL (12.5%)	TL30 (15%)	TL32 (17.5%)	TL35 (20%)
Capital cost [1]	Base	481	991	1,729	2,516	4,110
	High	1,723	3,553	6,048	9,923	15,566
Fuel Savings [2]	Base	7,804	15,655	25,167	32,175	41,699
	High	14,480	24,424	32,385	40,920	48,568
Net Savings [2] - [1]	Base	<b>7,323</b>	<b>14,664</b>	<b>23,438</b>	<b>29,659</b>	<b>37,589</b>
	High	<b>12,757</b>	<b>20,871</b>	<b>26,337</b>	<b>30,997</b>	<b>33,002</b>
2030 (EUR/lorry)	Cost assumptions	TL20 (20%)	TL30 * (30%)		TL32 (32%)	TL35 (35%)
Capital cost [1]	Base	2,608	10,803		14,881	18,584
	High	7,684	26,666		29,161	32,906
Fuel Savings [2]	Base	32,947	68,809		75,652	90,704
	High	40,812	81,437		95,014	115,334
Net Savings [2] - [1]	Base	<b>30,339</b>	<b>58,005</b>		<b>60,772</b>	<b>72,120</b>
	High	<b>33,128</b>	<b>54,771</b>		<b>65,853</b>	<b>82,429</b>

\* Results for TL30NL in 2030 are very similar to those for TL30



## 10.5 TCO-second use

**Table 16: Net economic savings from a second use perspective in 2025 and 2030 (EUR/lorry)**

2025 (EUR/lorry)	Cost assumptions	TL20 (10%)	TL30NL (12.5%)	TL30 (15%)	TL32 (17.5%)	TL35 (20%)
<i>Capital cost [1]</i>	<i>Base</i>	378	779	1,359	1,976	3,229
	<i>High</i>	1,354	2,791	4,752	7,797	12,231
<i>Fuel Savings [2]</i>	<i>Base</i>	5,791	11,624	18,712	23,926	31,023
	<i>High</i>	10,762	18,149	24,081	30,434	36,135
<i>Net Savings [2] - [1]</i>	<i>Base</i>	<b>5,413</b>	<b>10,846</b>	<b>17,354</b>	<b>21,950</b>	<b>27,794</b>
	<i>High</i>	<b>9,408</b>	<b>15,358</b>	<b>19,329</b>	<b>22,637</b>	<b>23,905</b>
2030 (EUR/lorry)	Cost assumptions	TL20 (20%)	TL30 * (30%)		TL32 (32%)	TL35 (35%)
<i>Capital cost [1]</i>	<i>Base</i>	2,049	8,488		11,692	14,601
	<i>High</i>	6,037	20,952		22,912	25,854
<i>Fuel Savings [2]</i>	<i>Base</i>	24,081	50,294		55,299	66,232
	<i>High</i>	29,830	59,451		69,306	84,055
<i>Net Savings [2] - [1]</i>	<i>Base</i>	<b>22,032</b>	<b>41,805</b>		<b>43,608</b>	<b>51,630</b>
	<i>High</i>	<b>23,793</b>	<b>38,499</b>		<b>46,394</b>	<b>58,200</b>

\* Results for TL30NL in 2030 are very similar to those for TL30

## 10.6 Sensitivity – economic impacts with varying international oil price

Section 6.2.4.2 of the Impact Assessment shows the net economic savings (from different perspectives) from different CO<sub>2</sub> target levels. The fuel price projections used for the calculation of the fuel savings are those used in the Reference Scenario 2016<sup>78</sup>, both for the baseline and for the policy options.

As a sensitivity analysis, it is relevant to assess the changes to the net economic savings in case of different international fuel price projections. Therefore a scenario is considered assuming a different evolution of the fuel prices. The new projected fuel price used for this sensitivity in 2030 is about 25% lower than in the assumptions used for the Reference Scenario 2016.

The economic analysis was repeated with the lower international fuel prices, both in the baseline and for the various options for the target levels (using the base cost assumptions).

Table 17, Table 18 and Table 19 show the results for the net economic savings from a societal perspective, a first use perspective and a second use perspective, respectively.

This shows that even with the lower oil prices, the CO<sub>2</sub> targets continue to have a positive economic effect for all levels considered, with fuel savings continuing to significantly outweigh increased capital expenditures for more efficient vehicles.

<sup>78</sup> [https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft\\_publication\\_REF2016\\_v13.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf)

**Table 17: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/lorry) under different TL options in case of a lower international fuel price and using the base cost assumptions**

2025	<b>TL20 (10%)</b>	<b>TL30NL (12.5%)</b>	<b>TL30 (15%)</b>	<b>TL32 (17.5%)</b>	<b>TL35 (20%)</b>
<i>Net Savings</i>	5,888	12,028	19,872	24,992	31,568
2030	<b>TL20 (20%)</b>	<b>TL30* (30%)</b>		<b>TL32 (32%)</b>	<b>TL35 (35%)</b>
<i>Net Savings</i>	24,888	42,481		41,588	43,910

\* Results for TL30NL in 2030 are very similar to those for TL30

**Table 18: Net economic savings from a first use (5 years) perspective in 2025 and 2030 (EUR/lorry) under different TL options in case of a lower international fuel price and using the base cost assumptions**

2025	<b>TL20 (10%)</b>	<b>TL30NL (12.5%)</b>	<b>TL30 (15%)</b>	<b>TL32 (17.5%)</b>	<b>TL35 (20%)</b>
<i>Net Savings</i>	5,372	10,750	17,146	21,616	27,529
2030	<b>TL20 (20%)</b>	<b>TL30* (30%)</b>		<b>TL32 (32%)</b>	<b>TL35 (35%)</b>
<i>Net Savings</i>	22,103	40,803		41,859	49,444

\* Results for TL30NL in 2030 are very similar to those for TL30

**Table 19: Net economic savings from a second use perspective in 2025 and 2030 (EUR/lorry) under different TL options in case of a lower international fuel price and using the base cost assumptions**

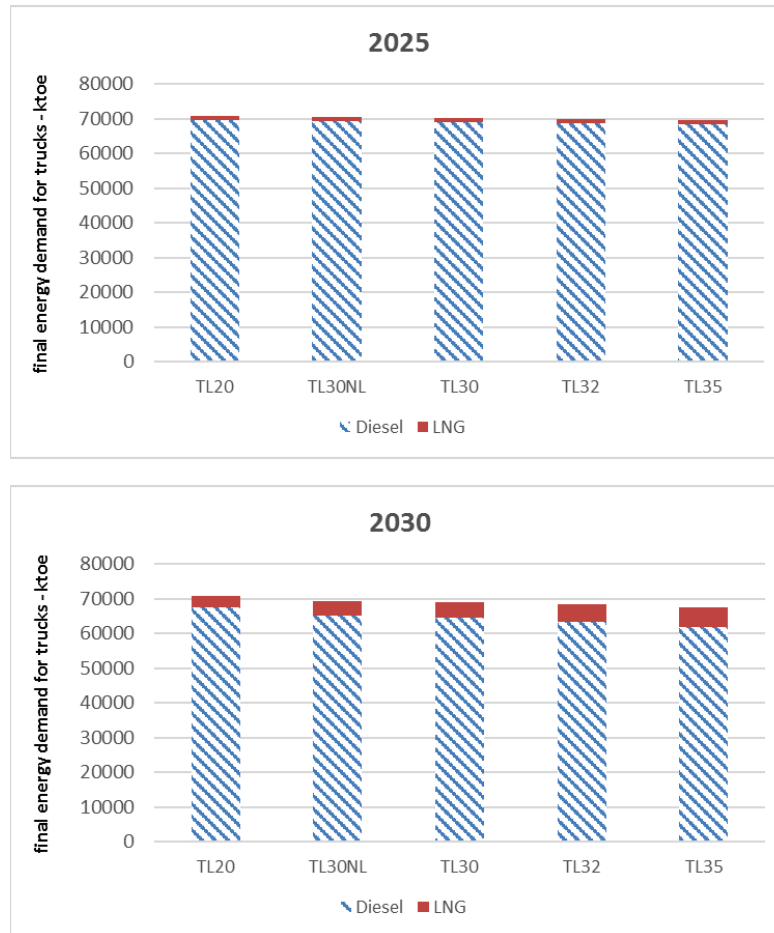
2025	<b>TL20 (10%)</b>	<b>TL30NL (12.5%)</b>	<b>TL30 (15%)</b>	<b>TL32 (17.5%)</b>	<b>TL35 (20%)</b>
<i>Net Savings</i>	3,965	7,940	12,675	15,968	20,303
2030	<b>TL20 (20%)</b>	<b>TL30* (30%)</b>		<b>TL32 (32%)</b>	<b>TL35 (35%)</b>
<i>Net Savings</i>	16,012	29,232		29,783	35,072

\* Results for TL30NL in 2030 are very similar to those for TL30

## 10.7 Energy system impact of different target level options

Figure 15 and Table 20 show the impact of the different TL options on the final energy demand for lorries in 2025 and 2030 using the base cost assumptions.

**Figure 15: Final energy demand (ktoe) for lorries over the period in 2025 and 2030 under different TL options using the base cost assumptions**



**Table 20: Final energy demand (ktoe) for lorries in 2025 and 2030 under different TL options using the base cost assumptions**

Option	2025		2030	
	Diesel	LNG	Diesel	LNG
Baseline	70,802	499	71,377	1,301
TL20	69,703	1,019	67,596	3,163
TL30NL	69,395	1,079	65,135	4,167
TL30	69,061	1,148	64,505	4,443
TL32	68,707	1,225	63,352	5,012
TL35	68,302	1,320	61,877	5,690

## 10.8 Freight (HDV) transport impact of different target level options

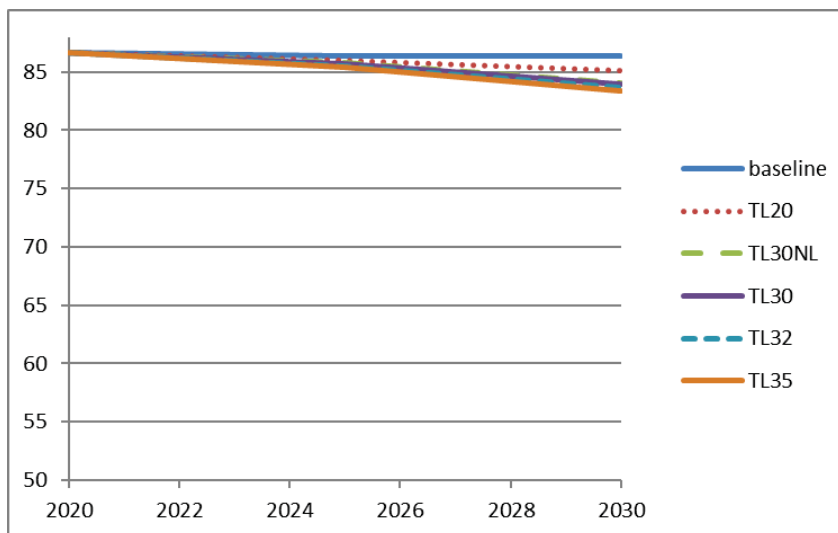
Freight transport activity is projected to increase slightly over time in the baseline scenario due to increased economic activity. The decrease in the fuel costs lowers freight costs, and consequently increases freight transport activity. However, as shown in Table 21, for all the options assessed, this increase remains limited in the range of 0.2% to 0.4% in 2025 and 0.5% to 0.9% in 2030 depending on the target level option.

**Table 21: Freight (HDV) transport activity (Gtkm) evolution with respect to the baseline in the period 2020-2030 under different TL options using the base cost assumptions**

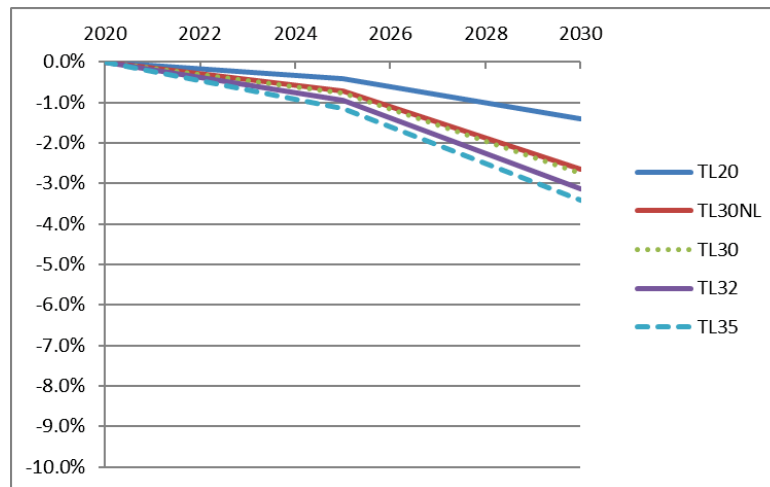
	2020	2025	2030
Baseline (Gtkm)	2,007	2,165	2,319
TL20	0.0%	0.2%	0.5%
TL30NL	0.0%	0.3%	0.9%
TL30	0.0%	0.3%	0.9%
TL32	0.0%	0.3%	0.9%
TL35	0.0%	0.4%	0.9%

As shown in Figure 16 and Figure 17, the target levels have a limited impact on the reduction of the total costs of freight (HDV) transport per activity, by less than 1% in 2025 and in the order of 1 to 3% in 2030.

**Figure 16: Evolution of freight (HDV) transport total costs per activity (Meuro/Gtkm) in the period 2020-2030 under different TL options using the base cost assumptions**



**Figure 17: Evolution of freight (HDV) transport total costs with respect to the baseline in the period 2020-2030 under different TL options using the base cost assumptions**



These results are also consistent with the analysis using EXIOMOD. As shown in Table 22, prices for “other land transportation services”, which includes freight transport, decrease by 2.5%–3.0% compared to the baseline in 2025 and by 3.0%–4.5% in 2030 depending on the target level. These price decreases are of the same order of magnitude as the decreases in costs shown in Figure 17.

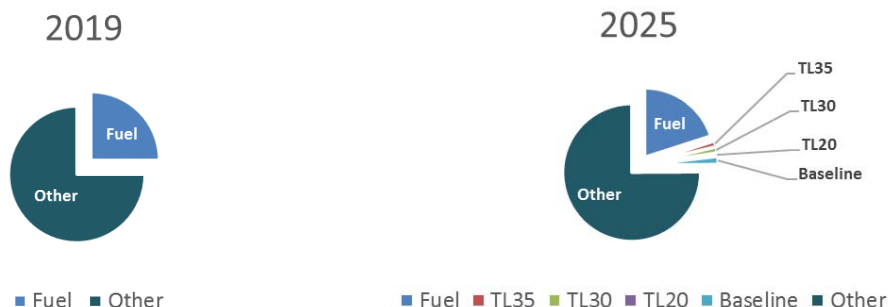
**Table 22: Prices of “other land transportation services” compared to the baseline<sup>79</sup>**

Option	2025	2030
TL20	-2.5%	-3.0%
TL30	-2.7%	-3.8%
TL30NL	-2.6%	-3.6%
TL32	-2.8%	-4.1%
TL35	-3.0%	-4.5%

Figure 18 shows that some fuel savings occur already under the baseline, and stricter targets would reduce fuel consumption even further. The other costs would only increase slightly due to the purchase of fuel-saving technologies.

<sup>79</sup> Including freight and passenger transport

**Figure 18: Fuel costs incidence on transport operator costs**



**10.9 Macro-economic impacts, including employment (EXIOMOD results), of different target level options**

**Table 23: GDP impacts in the baseline (million euros) and percentage change from the baseline under selected options for the CO<sub>2</sub> target level when using the high cost assumptions**

Option for target level (high cost assumptions)	2025	2030
Baseline (M EUR)	15,803,228	16,912,315
TL 20	0.00%	0.01%
TL 30	0.01%	0.02%

**Table 24: Total number of jobs (000s) under the baseline and percentage changes to the baseline under different policy options when using the high cost assumptions**

Option for target level (high cost assumptions)	2025	2030
Baseline (000s)	236,347	242,105
TL 20	0.02%	0.05%
TL 30	0.03%	0.09%

**Table 25: Total employment impacts for key sectors in terms of percentage changes to the baseline when using the base cost assumptions**

2025 - base cost assumptions					
Sector/Option	TL20	TL30 NL	TL30	TL32	TL35
Manufacturing of refined petroleum products	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%
Manufacturing of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%

Transportation services <sup>80</sup>	0.0%	0.0%	0.1%	0.1%	0.1%
Other land transportation services <sup>81</sup>	0.1%	0.2%	0.3%	0.3%	0.4%
Mining fossil fuel (no petroleum)	0.0%	0.0%	0.0%	0.0%	0.0%
Extraction crude petroleum	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%
Construction	0.0%	0.0%	0.0%	0.0%	0.1%
Sale and maintenance of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%
Manufacturing industry (no motor-vehicles)	0.0%	0.0%	0.0%	0.0%	0.0%
<b>2030 - base cost assumptions</b>					
<b>Sector/Option</b>	<b>TL20</b>	<b>TL30 NL</b>	<b>TL30</b>	<b>TL32</b>	<b>TL35</b>
Manufacturing of refined petroleum products	-0.2%	-0.4%	-0.4%	-0.5%	-0.5%
Manufacturing of motor-vehicles	0.0%	0.0%	0.0%	0.1%	0.1%
Transportation services	0.1%	0.2%	0.3%	0.3%	0.4%
Other land transportation services	0.4%	0.8%	0.8%	0.9%	0.9%
Mining fossil fuel (no petroleum)	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
Extraction crude petroleum	-0.2%	-0.5%	-0.5%	-0.6%	-0.7%
Construction	0.0%	0.1%	0.1%	0.2%	0.2%
Sale and maintenance of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%
Manufacturing industry (no motor-vehicles)	0.0%	0.0%	0.0%	0.0%	0.0%

**Table 26: Total employment impacts for key sectors in terms of percentage changes to the baseline when using the high cost assumptions**

<b>2025 - high cost assumptions</b>		
<b>Sector/Option</b>	<b>TL 20</b>	<b>TL 30</b>
Manufacturing of refined petroleum products	-0.12%	-0.20%
Manufacturing of motor-vehicles	0.02%	0.03%
Transportation services <sup>82</sup>	0.09%	0.15%
Other land transportation services <sup>83</sup>	0.17%	0.26%
Mining fossil fuel (no petroleum)	-0.03%	-0.05%
Extraction crude petroleum	-0.16%	-0.26%
Construction	0.04%	0.07%
Sale and maintenance of motor-vehicles	-0.01%	0.00%
Manufacturing industry (no motor-vehicles)	0.01%	0.02%

<sup>80</sup> Including transport via railways; pipelines; sea; inland water; air

<sup>81</sup> Including freight and passenger transport

<sup>82</sup> Including transport via railways; pipelines; sea; inland water; air

<sup>83</sup> Including freight and passenger transport

<b>2030 - high cost assumptions</b>		
Manufacturing of refined petroleum products	-0.28%	-0.47%
Manufacturing of motor-vehicles	0.04%	0.08%
Transportation services	0.26%	0.48%
Other land transportation services	0.43%	0.60%
Mining fossil fuel (no petroleum)	-0.08%	-0.13%
Extraction crude petroleum	-0.40%	-0.69%
Construction	0.12%	0.23%
Sale and maintenance of motor-vehicles	0.02%	0.02%
Manufacturing industry (no motor-vehicles)	0.02%	0.05%



**Table 27: Impacts on the turnover of the most affected sectors as a percentage change from the baseline when using the base cost assumptions**

<b>2025 - base cost assumptions</b>					
<b>Sector/Option</b>	<b>TL20</b>	<b>TL30NL</b>	<b>TL30</b>	<b>TL32</b>	<b>TL35</b>
Manufacturing of refined petroleum products	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%
Manufacturing of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%
Transportation services <sup>84</sup>	0.0%	0.0%	0.1%	0.1%	0.0%
Other land transportation services <sup>85</sup>	0.1%	0.2%	0.3%	0.4%	0.6%
Mining fossil fuel (no petroleum)	0.0%	0.0%	0.0%	0.0%	-0.1%
Extraction crude petroleum	-0.1%	-0.1%	-0.1%	-0.2%	-0.3%
Construction	0.0%	0.0%	0.0%	0.0%	0.0%
Sale and maintenance of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%
Manufacturing industry (no motor-vehicles)	0.0%	0.0%	0.0%	0.0%	0.0%
<b>2030 - base cost assumptions</b>					
Manufacturing of refined petroleum products	-0.2%	-0.4%	-0.4%	-0.5%	-0.5%
Manufacturing of motor-vehicles	0.0%	0.0%	0.0%	0.0%	0.0%
Transportation services	0.1%	0.2%	0.3%	0.3%	0.0%
Other land transportation services	0.6%	1.4%	1.6%	1.9%	2.4%
Mining fossil fuel (no petroleum)	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%
Extraction crude petroleum	-0.2%	-0.5%	-0.6%	-0.6%	-0.8%
Construction	0.0%	0.1%	0.1%	0.1%	0.2%
Sale and maintenance of motor-vehicles	-0.1%	-0.1%	-0.1%	-0.1%	0.0%
Manufacturing industry (no motor-vehicles)	0.0%	0.0%	0.0%	0.0%	0.0%

<sup>84</sup> Including transport via railways; pipelines; sea; inland water; air

<sup>85</sup> Including freight and passenger transport

**Table 28: Impacts on the turnover of the most affected sectors as a percentage change from the baseline when using the high cost assumptions**

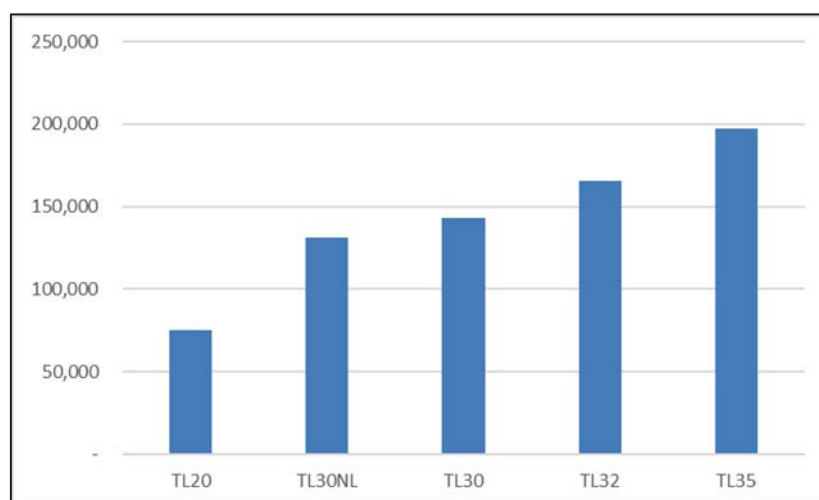
<b>2025 - high cost assumptions</b>		
<b>Sector/Option</b>	<b>TL 20</b>	<b>TL 30</b>
Manufacturing of refined petroleum products	-0.13%	-0.21%
Manufacturing of motor-vehicles	0.01%	0.02%
Transportation services <sup>86</sup>	0.08%	0.13%
Other land transportation services <sup>87</sup>	0.46%	0.77%
Mining fossil fuel (no petroleum)	-0.04%	-0.07%
Extraction crude petroleum	-0.17%	-0.28%
Construction	0.04%	0.06%
Sale and maintenance of motor-vehicles	-0.01%	-0.02%
Manufacturing industry (no motor-vehicles)	0.00%	0.01%
<b>2030 - high cost assumptions</b>		
Manufacturing of refined petroleum products	-0.30%	-0.51%
Manufacturing of motor-vehicles	0.03%	0.05%
Transportation services	0.24%	0.44%
Other land transportation services	1.46%	2.67%
Mining fossil fuel (no petroleum)	-0.12%	-0.20%
Extraction crude petroleum	-0.44%	-0.77%
Construction	0.10%	0.19%
Sale and maintenance of motor-vehicles	-0.05%	-0.05%
Manufacturing industry (no motor-vehicles)	0.00%	0.01%

<sup>86</sup> Including transport via railways; pipelines; sea; inland water; air

<sup>87</sup> Including freight and passenger transport

## 10.10 Environmental impacts of different target level options: CO<sub>2</sub> emissions and air pollutant emissions

**Figure 19: Cumulative reduction (kt) compared to the baseline over the period 2020-2035 of HDV CO<sub>2</sub> emissions for EU-28 using the base cost assumptions**



**Table 29: NO<sub>x</sub> and PM<sub>2.5</sub> emissions of road transport in EU-28: % reduction compared to the baseline using the base cost assumptions**

	NO <sub>x</sub> emissions		PM <sub>2.5</sub> emissions	
	2025	2030	2025	2030
<b>TL20</b>	-0.3%	-1.3%	-0.1%	-0.2%
<b>TL30NL</b>	-0.4%	-2.8%	-0.1%	-0.3%
<b>TL30</b>	-0.5%	-3.2%	-0.1%	-0.4%
<b>TL32</b>	-0.6%	-3.9%	-0.1%	-0.5%
<b>TL35</b>	-0.8%	-4.7%	-0.1%	-0.6%

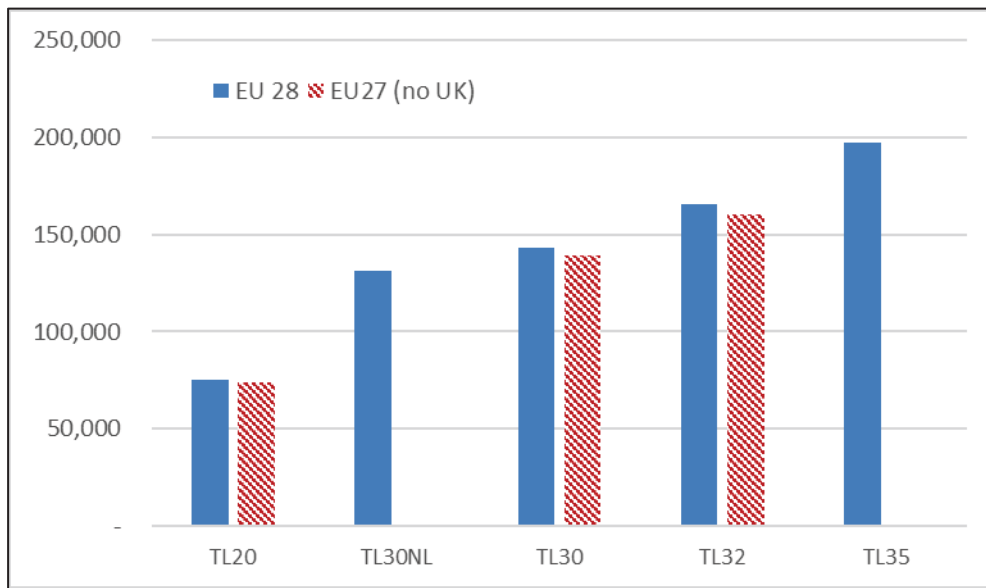
## 10.11 Sensitivity – results for EU-27, without UK

Some sensitivity analysis was performed in order to estimate the impact of Brexit on some results of the modelling.

This showed that the new lorry fleet composition in 2025 and 2030, i.e. the share of diesel and LNG vehicles in the new fleet, would not be affected. The figures shown in Table 11 with regards to the net economic savings would thus equally apply for EU-27.

In terms of CO<sub>2</sub> emissions, Figure 20 shows the difference between EU-28 and EU-27 in terms of the cumulative emission reduction (kt) compared to the baseline over the period 2020-2035. While emission reductions are obviously slightly lower for EU-27, the overall trends across the target level options are not affected.

**Figure 20: Cumulative reduction (kt) compared to the baseline over the period 2020-2035 of HDV CO<sub>2</sub> emissions for EU-28 and for EU-27, without UK, using the base cost assumptions**



### 10.12 Contribution to the ESR targets

**Table 30: Evolution of GHG emissions between 2005 (100%) and 2030 under the baseline and different policy options**

	2005	2010	2015	2020	2025	2030
<b>baseline HDV</b>	100%	96%	95%	91%	86%	83%
<b>Cars + vans proposal</b>	100%	96%	95%	91%	85%	79%
<b>Cars + vans+HDV TL20</b>	100%	96%	95%	91%	85%	78%
<b>Cars +vans + HDV TL30</b>	100%	96%	95%	91%	85%	78%
<b>Cars + vans + HDV TL35</b>	100%	96%	95%	91%	84%	77%
<b>EuCo30</b>	100%	96%	94%	88%	81%	75%

### 10.13 Penalties – economic impacts

The economic impact of financial penalties will depend on the target level set as this influences the marginal technology costs.

Table 31 summarises the marginal technology costs for meeting the different target levels assessed, based on the base cost assumptions.

**Table 31: Marginal technology costs (€ / (g CO<sub>2</sub>/km)) in 2025 and 2030**

<b>Option</b>	<b>2025</b>	<b>2030</b>
TL20	27	75
TL30NL	39	485
TL30	65	475
TL32	92	827
TL35	159	991

HDVs have an average lifetime mileage of around 1.2 million km, which is about six times higher than LDVs. On that basis, the penalty of €95 per g CO<sub>2</sub>/km of target exceedance, which applies under the EU Regulations for LDV, would translate into a €570 per g CO<sub>2</sub>/km penalty for HDVs<sup>88</sup>.

As

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<sup>88</sup> Taking into account the average payloads as simulated in VECTO and the relative share of the different vehicle groups in the fleet, this translates into a penalty of around €50 per gCO<sub>2</sub>/tkm exceedance of the target.

Table 31 shows, such penalty would exceed the marginal technology costs in the HDV sector for most target level options, but not for the most ambitious ones in 2030.

## 11 ANNEX 11: DISTRIBUTION OF THE EU FLEET-WIDE TARGET BETWEEN THE VARIOUS LORRY FAMILIES (SUB-)GROUPS AND MANUFACTURERS

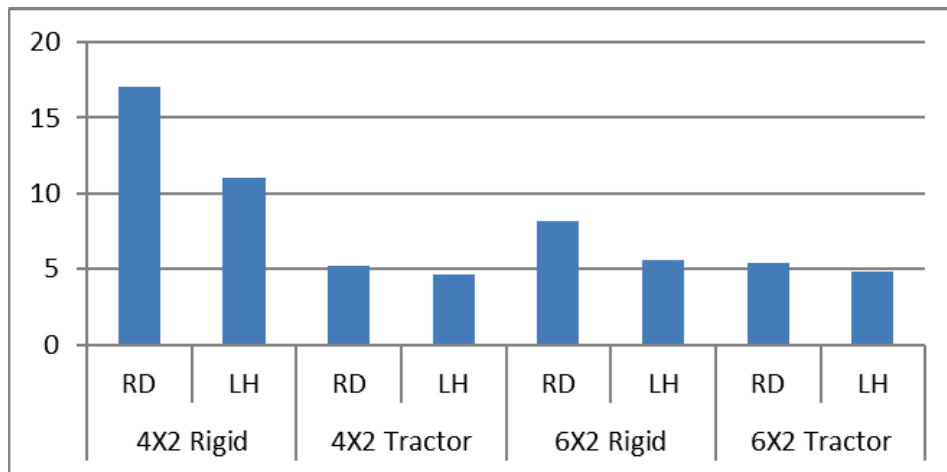
### 11.1 Sub-group targets

As described in Section 5.2 of the Impact Assessment, in order to take into account the technical and business characteristics of the various lorries, separate emission targets should be defined for each HDV sub-group (see Annex 8.2).

Within each of the vehicle groups differences occur depending on the mission profile of the vehicles. For the vehicle groups considered in this Impact Assessment, the two most relevant mission profiles listed in the Certification Regulation are Long Haul (LH) and Regional Delivery (RD).

Figure 21 illustrates the differences in fuel consumption between the four vehicle groups considered, distinguishing the LH and RD mission profiles for each of them.

**Figure 21: Average fuel consumption (l/100 tkm) (2016) for the four vehicle groups considered in this impact assessment under the RD and LH mission profiles**



### 11.2 Assessment of compliance

Under option Distribution 2 starting from the 8 sub-group targets, a single target for each manufacturer would be defined. These manufacturer targets would be calculated as a weighted average of the sub-group targets, taking into account:

- (i) the fleet composition of each manufacturer, i.e. the number of vehicles registered by that manufacturer within each sub-group;
- (ii) the average mileage and payload of vehicles within each sub-group, as these determine the total CO<sub>2</sub> emissions of a vehicle.

The different sub-groups are characterised by different payloads and lifetime mileages. Therefore, the total CO<sub>2</sub> emissions of a vehicle with a given emission level in g CO<sub>2</sub>/tkm will vary depending on the sub-group it belongs to. In order to describe this dependency, a **utility parameter** is defined for each sub-group, which would be used for the weighting of the sub-group targets and emissions:

$$(\text{sub-group utility parameter}) = ((\text{mileage} * \text{payload}) \text{ of sub-group}) / (\text{normalisation parameter})$$

[equ. 11.1]



The (*normalisation parameter*) can in principle be arbitrarily chosen. As the simplest and most transparent approach, it is suggested that the (*mileage \* payload*) of the vehicles in the "major" sub-group 5-LH (representing more than 60% of all vehicles in the fleet and an even higher share of CO<sub>2</sub> emissions) would be used for this purpose. This would mean that the CO<sub>2</sub> emissions of all other sub-groups would be expressed in relation to this major sub-group:

$$(\textit{normalisation parameter}) = ((\textit{mileage * payload}) \textit{ of vehicles in sub-group 5-LH})$$

**[equ. 11.2]**

Using the abovementioned approach, the OEM specific CO<sub>2</sub> targets would be defined as follows:

$$\textit{OEM target} = \sum (\textit{sub-group utility parameter}) * (\textit{sub-group target}) * (\textit{sub-group share in OEM fleet})$$

**[equ. 11.3]**

For assessing compliance, the total CO<sub>2</sub> emissions of the OEM are calculated as follows:

$$\textit{OEMtotCO}_2 = \sum (\textit{sub-group utility parameter}) * (\textit{OEM average CO}_2 \textit{ emissions in sub-group}) * (\textit{sub-group share in OEM fleet})$$

**[equ. 11.4]**

The sums shown above are over all sub-groups.

Compliance is achieved by an OEM if  $\textit{OEMtotCO}_2 < \textit{OEM target}$

## 12 ANNEX 12: WEIGHTING OF MISSION PROFILES FOR CALCULATING CO<sub>2</sub> EMISSIONS FOR THE PURPOSE OF ASSESSING COMPLIANCE WITH CO<sub>2</sub> TARGETS

### 12.1 Mission profiles in VECTO

For each vehicle VECTO provides a series of CO<sub>2</sub> emission values corresponding to different "mission profiles". A mission profile is the simulation of the vehicle following a certain driving pattern, carrying a defined payload. For the vehicle categories 4, 5, 9 and 10 used for the delivery of goods, a regional delivery (RD) and long-haul (LH) driving pattern have been defined, each covering a total distance of 100 km and reflecting typical acceleration and speed profiles of the two missions (e.g. a high share of motorway driving in the long-haul driving pattern).

Both mission profiles are combined with low load (LL) and reference load (RL) conditions, which correspond to an (almost) empty and a fully loaded lorry, respectively. The respective payloads have been defined on the basis of stakeholder input during the VECTO development, reflecting the fact that also on "empty trips" lorries carry some equipment (e.g. empty boxes, palettes etc.) and most "full load trips" are volume rather than weight constraint.

The payloads listed in Table 32 are thus attributed to the different mission profile (LL-RD, RL-RD, LL-LH, RL-LH) and vehicle groups simulated in VECTO:

**Table 32: VECTO payloads of different vehicle sub-groups and mission profiles**

Payloads (t)	LL-RD	RL-RD	LL-LH	RL-LH
<b>Group 4</b>	0.9	4.4	1.9	14
<b>Group 5</b>	2.6	12.9	2.6	19.3
<b>Group 10</b>				
<b>Group 9</b>	1.4	7.1	2.6	19.3

It should be noted that from the VECTO output alone no conclusions can be drawn on the relative shares of "empty" and "full load" trips of a lorry, but the operator can combine different VECTO data according to his own use pattern for non-regulatory purposes.

### 12.2 Weighting of VECTO mission profiles

As explained in Section 5.2 of this Impact Assessment, for the purpose of assessing compliance with regulatory CO<sub>2</sub> emission targets, the vehicle groups have been split further into "regional delivery (RD)" and "long haul (LH)" sub-groups.

Regulatory CO<sub>2</sub> emissions of vehicles in each of these sub-groups are calculated as a weighted average of emissions from the different mission profiles:

*(CO<sub>2</sub> emissions of a vehicle in sub-group s in gCO<sub>2</sub>/tkm) =*

*( $\sum_p$  (weight of mission profile p in sub-group s) \* (CO<sub>2</sub> emissions of the vehicle on mission profile p in gCO<sub>2</sub>)) /*

*( $\sum_p$  (weight of mission profile p in sub-group s) \* (payload of mission profile p in sub-group s) \* (mileage of mission profile p))*

With

Sub-groups  $s = 4\text{-RD}, 4\text{-LH}, 5\text{-RD}, 5\text{-LH}, 9\text{-RD}, 9\text{-LH}, 10\text{-RD}, 10\text{-LH}$ ;

mission profiles  $p = \text{LL-RD}, \text{RL-RD}, \text{LL-LH}, \text{RL-LH}$ ;

(payloads of mission profile  $p$  in sub-group  $s$ ) as given in table 1;

mileage of mission profile  $p = 100 \text{ km}$ .

In [equ. 12.1] vehicles from a certain sub-group may have contributions from all mission profiles. For example, vehicles in the "RD" sub-groups may have some contribution of the LH mission profile and vehicles in the "LH" sub-groups may have some contribution of the RD mission profile.

The weighting of the mission profiles in this equation – which can be different for the different sub-groups - should aim at reproducing the use of an (average) lorry within a vehicle sub-group under real driving conditions.

On the basis of expert judgement of the Commission's contractors and the JRC, the following driving shares for regional delivery and long haul missions have been derived, taking into account the specifics of the RD and LH driving trace in VECTO (for example, also the LH driving trace has some parts driven on regional routes etc.):

**Table 33: Relative shares of mileages driven for regional delivery and long haul missions in the RD and LH vehicle sub-groups**

Vehicle sub-groups	Regional delivery (RD)	Long haul (LH)
4-RD, 5-RD, 9-RD, 10-RD	90%	10%
4-LH, 5-LH, 9-LH, 10-LH	10%	90%

For separating the effects of loads (i.e. LL and RL) and driving patterns (i.e. RD and LH), the weights of the mission profiles in the sub-groups are represented as the product of the percentages in Table 33 and the weight of the "LL and RL type" mission profiles in the different groups. For this simplification, it was assumed that the relative shares of low load and reference load driving is the same for regional delivery and long haul missions:

(weight of profile  $l\text{-RD}$  in sub-group  $g\text{-RD}$ ) = 0,9 \*(weight of profile  $l$  in group  $g$ )

(weight of profile  $l\text{-RD}$  in sub-group  $g\text{-LH}$ ) = 0,1 \*(weight of profile  $l$  in group  $g$ )

(weight of profile  $l\text{-LH}$  in sub-group  $g\text{-RD}$ ) = 0,1 \*(weight of profile  $l$  in group  $g$ )

(weight of profile  $l\text{-LH}$  in sub-group  $g\text{-LH}$ ) = 0,9 \*(weight of profile  $l$  in group  $g$ )

with  $l = \text{LL}, \text{RF}$  and  $g = 4, 5, 9, 10$

[equ. 12.2]

In the following the values for the parameters on the left hand side of [equ. 12.2] are determined by relating the average payloads of vehicle sub-groups, when calculated as weighted averages of emissions from the different mission profiles, to real driving emission values:

(average payload of sub-group  $s$ ) =

$$\sum_p (\text{weight of mission profile } p \text{ in sub-group } s) * (\text{payload of mission profile } p \text{ in sub-group } s)$$

with  $p = \text{LL-RD}, \text{RL-RD}, \text{LL-LH}, \text{RL-LH}$  and

s = 4-RD, 4-LH, 5-RD, 5-LH, 9-RD, 9-LH, 10-RD, 10-LH;

(payload of mission profile *p* in sub-group *s*) as given in Table 32.

[equ. 12.3]

The average payloads of the sub-groups have been determined by Commission contractors analysing operational data of vehicles as well as information from literature. From the empirical information available, vehicles could not be linked to a predominant regional delivery or long haul use. Therefore, for solving [equ. 12.3], it has been assumed that all vehicles in a certain group (*g* = 4, 5, 9, 10) belong to the statistically predominant sub-group within this group (i.e. 4-RD, 5-LH, 9-RD, 10-LH).

Inserting [equ. 12.2] into [equ. 12.3] results in four conditions with four free parameters, from which the (weights of profile *l* in group *g*) of [equ. 12.2] can be uniquely determined, as shown in the table below:

**Table 34: Weightings of profile types *l* = LL, RL in the different vehicle groups *g***

Vehicle group ( <i>g</i> )	<i>l</i> = Low load (LL)	<i>l</i> = Reference load (RL)
4	0.5	0.5
5	0.3	0.7
9	0.3	0.7
10	0.3	0.7

With [equ. 12.2] one can then calculate the following weightings for mission profiles.

**Table 35: Weighting of mission profiles in the different vehicle sub-groups**

Sub-group ( <i>s</i> )	LL-RD	RL-RD	LL-LH	RL-LH
4-RD	0.45	0.45	0.05	0.05
4-LH	0.05	0.05	0.45	0.45
5-RD	0.27	0.63	0.03	0.07
5-LH	0.03	0.07	0.27	0.63
9-RD	0.27	0.63	0.03	0.07
9-LH	0.03	0.07	0.27	0.63
10-RD	0.27	0.63	0.03	0.07
10-LH	0.03	0.07	0.27	0.63

These weightings have been used for calculating the cost curves discussed in Chapter 6 of the Impact Assessment.