EUROPEAN
COMMISSION

Brussels, 8.11.2017
SWD(2017) 650 final

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 emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast)

{COM(2017) 676 final} - {SWD(2017) 651 final}

Table of Contents

List of figures

GLOSSARY - ACRONYMS AND DEFINITIONS

ACEA	Federation of European Car Manufacturers
BEV	Battery Electric Vehicle
CNG	Compressed Natural Gas
CO_2	Carbon dioxide
EMIS	Emission Measurements In the automotive Sector (Committee of the European Parliament)
ESR	Effort Sharing Regulation
ETS	EU Emission Trading System
EV	Electric Vehicle: covers BEV, FCEV and PHEV
FCEV	Fuel Cell Electric Vehicle
FCM	Fuel Consumption Measurement
GDP	Gross Domestic Product
GHG	Greenhouse gas(es)
HDV	Heavy-Duty Vehicles, i.e. lorries, buses and coaches (vehicles of more than 3.5 tons)
HEV	Hybrid Electric Vehicle (not including PHEV)
ICEV	Internal Combustion Engine Vehicle
IEA	International Energy Agency
LCA	Life-Cycle Assessment
LCV	Light Commercial Vehicle(s): van(s)
LDV	Light-Duty Vehicle(s), i.e. passenger cars and vans
LPG	Liquified Petroleum Gas
LNG	Liquefied Natural Gas
MAC	Mobile Air Conditioning
NEDC	New European Driving Cycle
NGO	Non-Governmental Organisation
NO_x	Nitrogen oxides (nitric oxide (NO) and nitrogen dioxide (NO_2))
O&M	Operation and Maintenance
OECD	Organisation for Economic Co-operation and Development
OBD	On-Board Diagnostics
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate matter
REEV	Range Extended Electric Vehicle (sub-group of PHEV)
SAM	Scientific Advice Mechanism
TLC	CO_2 Target Level for passenger Cars (policy option)
TLV	CO_2 Target Level for Vans (policy option)
TTW emissions	"Tank-to-wheel" emissions: emissions from the vehicle tailpipe that occur during the drive cycle of vehicles.
WLTP	Worldwide Harmonised Light Vehicles Test Procedure
WTT emissions	"Well-to-tank" emissions: emission occurring during fuel (incl. electricity, hydrogen) production and transport
WTW emissions	"Well-to-wheel" emissions: sum of TTW and WTT emissions

1 INTRODUCTION

1.1 Policy context

In his **State of the Union Address 2017**[1] President Juncker put it very clearly: while the car industry is a key sector for Europe making world-class products, EU manufacturers will need to invest in the clean cars of the future in order to maintain their strong position. In addition, President Juncker stated "I want Europe to be the leader when it comes to the fight against climate change" and announced that "the Commission will shortly present proposals to reduce the carbon emissions of our transport sector".

The **automotive industry is crucial for Europe's prosperity**, providing jobs for 12 million people in manufacturing, sales, maintenance and transport and accounting for 4% of the EU's GDP[2], including in sectors such as steel, aluminium, plastics, chemicals, textiles and ICT. The EU is among the world's biggest producers of motor vehicles and demonstrates technological leadership in this sector.

EU industry, in general, and the automotive sector, in particular, are currently facing **major transformations**. Digitalization and automation are transforming traditional manufacturing proceses. Innovation in electrified power trains, autonomous driving and connected vehicles constitute major challenges which may fundamentally transform the sector.

Furthermore, following the **Paris Agreement**[3], the world has committed to move towards a low-carbon economy. Many countries are now implementing policies for low-carbon transport, including vehicle standards, often in combination with measures to improve air quality. These developments represent an opportunity for the EU automotive sector to continue to innovate and adapt in order to ensure it remains a technological leader.

The EU 2030 framework for climate and energy includes a target of an at least 40% cut in domestic EU greenhouse gas (GHG) emissions compared to 1990 levels. The emission reductions in the Emissions Trading System (ETS) and non-ETS sectors amount to at least 43% and 30% by 2030 compared to 2005, respectively. The Commission has recently proposed 2030 GHG emission reduction targets for Member States under the Effort Sharing Regulation[4] (covering the non-ETS sectors, including road transport) as well as a revised Energy Efficiency Directive[5]. CO_2 standards for light-duty vehicles will help to meet the overall goals set out therein.

In addition to that, daily experience on traffic jams, the crisis over diesel cars emissions and the adoption of policy measures at local level to discorage car use in urban areas,

[1] President Jean-Claude Juncker's State of the Union Address 2017, http://europa.eu/rapid/press-release_SPEECH-17-3165_en.htm

[2] https://ec.europa.eu/growth/sectors/automotive_en

[3] http://unfccc.int/paris_agreement/items/9485.php

[4] Proposal for a Regulation on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 for a resilient Energy Union and to meet commitments under the Paris Agreement and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and other information relevant to climate change, COM(2016) 482 final

[5] 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 has proposed an energy efficiency target of 30% for 2030.

have contributed to making EU consumers more aware of the impact of road transport on health and air quality.

These developments take place globally since nowadays automotive industries are increasingly integrated in global value chains. Global automotive markets are expanding faster than ever before, notably in emerging markets such as India and China. The latter, in particular, is taking full advantage of the changing automotive landscape and according to a recent report by the International International Energy Agency , in 2016 it became the country with the highest share of electric vehicles.

In addition, EU sales of passenger cars relative to global sales have decreased from 34% before the crisis (2008/2009) to 20% today. This means that EU industry will have to consider not only increasing exporting volumes but also adapting to changing demands which will require more focus on innovation to retain competitiveness.

Until now, the ambitious emission reduction standards in place in Europe have represented a fundamental tool to push for innovation and investments in low carbon technologies. **But today, the EU is no longer the clear leader in this race, with the US, Japan, South Korea and China moving ahead very quickly.**

As highlighted in the recently adopted **Renewed Industrial Policy Strategy**[6], a modern and competitive automotive industry is key for the EU economy. However, for the sector to maintain its technological leadership and thrive in global markets, it will have to accelerate the transition towards more sustainable technologies and new business models. Only this will ensure that Europe will have the most competitive, innovative and sustainable industry of the 2030 and beyond.

The Commission's Communication **'Europe on the Move**: **An agenda for a socially fair transition towards clean, competitive and connected mobility for all'**[7] makes clear that we want to make sure 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. The Communication identifies that profound changes in how we enjoy mobility are underway and that the EU must be a leader in shaping this change at a global level, building on the key progress already made.

This Communication builds on the earlier Commission's European Strategy for Low-Emission mobility[8], published in July 2016, which set out an overall vision built on three pillars: (i) moving towards zero-emission vehicles; (ii) low emission alternative energy for transport; (iii) efficiency of the transport system.

The figure below presents an overview of the interlinkages between the various initiatives of the mobility package proposed by the Commission as well as other related EU climate, energy and transport related initiatives.

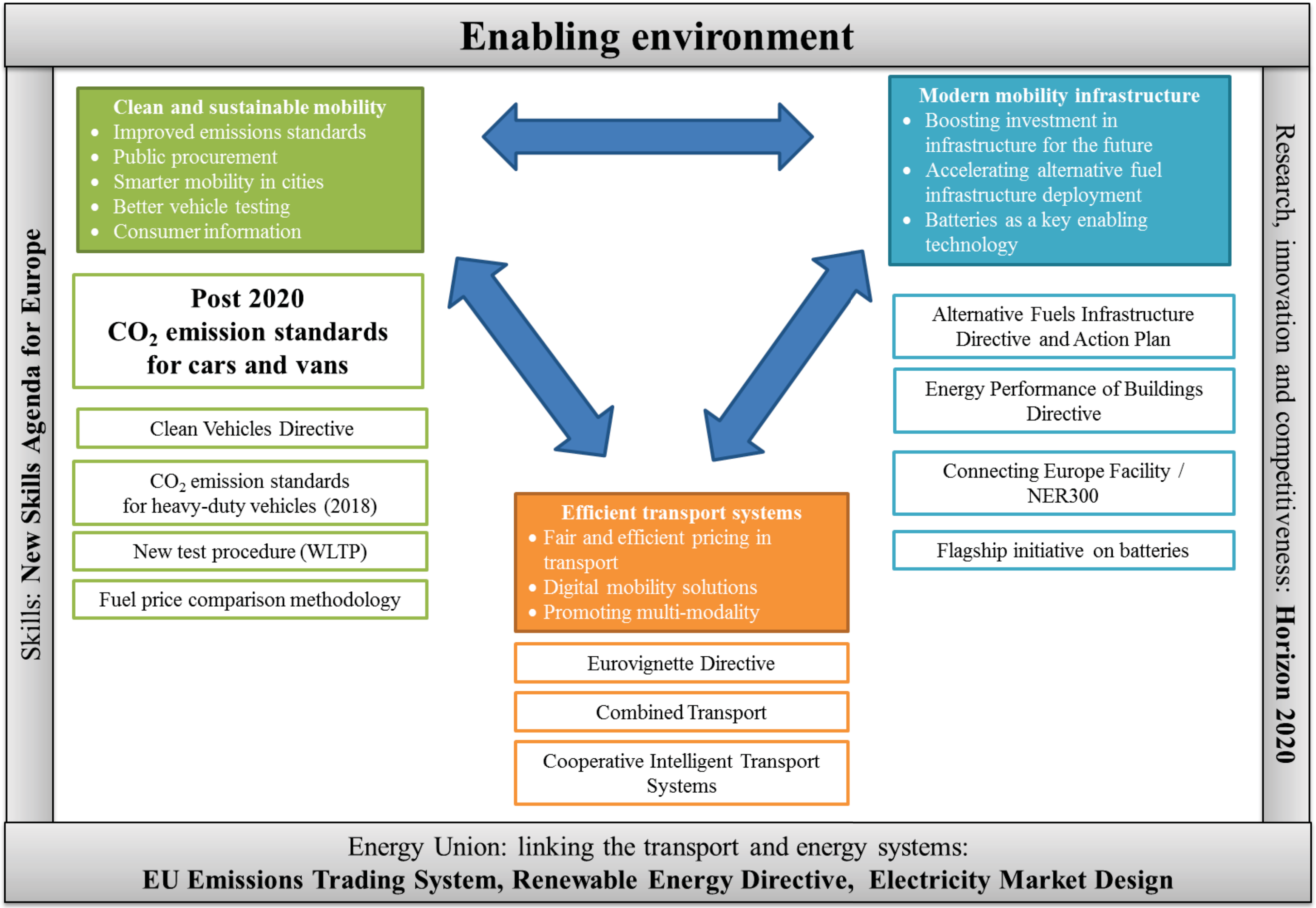
By pursuing an **integrated approach** looking both at the **demand and supply side** and by establishing an enabling environment and a clear vision and robust regulatory framework, the EU can create an environment that provides EU industry with the certainty and clarity needed to innovate and remain competitive for the future.

[6] COM(2017) 479 final

[7] COM(2017) 283 final

[8] COM(2016) 501 final

Figure 1: Overview of interlinkages between this initiative and other climate, energy and transport related initiatives at EU level



This builds on policies proposed or already implemented at national, regional and city level in the EU. Many Member States have set objectives to increase the share of zero and low emission vehicles, including both battery electric vehicles and plug-in hybrids, by 2020[9].

However, while some **Member States** have made good progress in achieving their objectives, the majority of Member States has made rather slow progress[10]. Even if the objectives were to be reached, the share of electric vehicles would remain low in the EU in relation to total vehicle registrations. Furthermore, three Member States, representing 35% of total new car registrations in the EU in 2016, have announced plans to phase out CO_2 emitting cars (see Table 1).

At the same time, many **cities** in the EU have implemented regulations which limit the access of certain vehicles to urban areas. Most restrictions are within the scope of so-called Low Emission Zones which either limit the city entry of the most polluting vehicles or, in some cases, impose higher fees for such vehicles if they enter the zone. Recently some cities have even announced plans to ban diesel and/or petrol cars (see Table 1).

Table 1: Overview of announcements at national and city level to encourage the use of zero- and low-emission vehicles

Geographical coverage	Announcements
Member States	
France	End the sale of new CO_2 emitting cars by 2040[11]
Netherlands	End the sale of new CO_2 emitting cars by 2030[12]
United Kingdom	End the sale of all new conventional petrol and diesel cars and vans by 2040[13]
Cities	
Paris (France)	Ban of diesel cars from 2024 and petrol cars from 2030[14]
Madrid (Spain) and Athens	Ban of diesel cars from 2025[15]

[9] Germany aims to become lead market for electric mobility and has set an objective of 1 million electric vehicles on the road by 2020; France aims for 2.4 million electric vehicles on the road by 2023; Poland aims to have 1 million electric vehicles on the road by 2025.

[10] Commission Staff Working Document (2017), Detailed Assessment of National Policy Frameworks under Directive 2014/94/EU. Greece, Malta, Romania, Slovenia, and the UK had not submitted their NPF by the cut-off date of 1 August 2017; data may include electric buses, LDVs and HDVs

[11] Ministère de la Transition écologique et solidaire (2017): Plan Climat, https://www.ecologique-solidaire.gouv.fr/sites/default/files/2017.07.06 - Plan Climat.pdf

[12] Coalition agreement of the new Dutch government, https://nltimes.nl/2017/10/10/new-dutch-governments-plans-coming-years

[13] UK Department for Environment Food & Rural Affairs (2017): UK plan for tackling roadside nitrogen dioxide concentrations, An overview, July 2017, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/633269/air-quality-plan-overview.pdf

[14] Mairie de Paris (2017): Fin des véhicules diesel et essence: réaction de la Ville de Paris, Communiqué de presse, 12/10/2017, https://presse.paris.fr/wp-content/uploads/2017/10/Fin-des-v%C3%A9hicules-diesel-et-essence-r%C3%A9action-de-la-Ville-de-Paris.pdf

(Greece)	
Oxford (UK)	Ban of all non-electric vehicles in the city centre by 2035[16]

A policy framework that further stimulates the accelerated uptake of zero- and low-emission vehicles would complement the on-going efforts to address air quality problems and would be well aligned with on-going action at city, regional, and national level. Zero-emission vehicles do not only reduce CO_2 emissions from road transport but deliver also in terms of air pollutant and noise emission free transport.

1.2 Legal context

The EU has in place two Regulations setting CO_2 targets for new passenger cars and vans, respectively, which are based upon Article 192 of the TFEU (Environment chapter):

- **Regulation (EC) No 443/2009** setting a fleet-wide average target for new passenger cars of 130 g CO_2/km from 2015 and 95g CO_2/km from 2021, and
- **Regulation (EU) No 510/2011** setting a fleet-wide average target for new light commercial vehicles of 175 g CO_2/km from 2017 and 147 gCO_2/km from 2020.

These regulations have been amended in 2014 through Regulation (EU) No 333/2014 and Regulation (EU) No 254/2014 in order to define the modalities for implementing the 2020/2021 targets.

Both Regulations request the Commission to carry out a review by the end of 2015, and to report on it to the Council and the European Parliament, accompanied, if appropriate, by a proposal to amend the Regulations for the period beyond 2020.

The abovementioned emission targets have been set on the basis of the New European Driving Cycle (NEDC) test cycle. From 1 September 2017 on, a new regulatory test procedure, the World Harmonised Light Vehicles Test Procedure (WLTP)[17], developed in the context of the UNECE, has been introduced under the type approval legislation for determining the emissions of CO_2 and the new targets will need to take this into account. Furthermore, consumer information on the fuel consumption and CO_2 emission of new passenger cars under Directive 1999/94/EC should be based on WLTP as of 1 January 2019[18].

[15] BBC (2017): Four major cities move to ban diesel vehicles by 2025, http://www.bbc.com/news/science-environment-38170794

[16] Reuters (2017): Oxford to become first UK city to ban petrol and diesel cars from center, http://www.reuters.com/article/us-britain-autos-oxford/oxford-to-become-first-uk-city-to-ban-petrol-and-diesel-cars-from-center-idUSKBN1CH1IQ?utm_source=34553&utm_medium=partner

[17] Commission Regulation (EU) 2017/1151 of 1 June 2017

[18] Commission Recommendation (EU) 2017/948 of 31 May 2017 on the use of fuel consumption and CO2 emission values type-approved and measured in accordance with the World Harmonised Light Vehicles Test Procedure when making information available for consumers pursuant to Directive 1999/94/EC

1.3 Evaluation of the implementation

An extensive evaluation of the existing Regulations was carried out as part of REFIT. This was completed in April 2015 and the final report of the consultants has been published[19].

The evaluation report assessed the Regulations against the objectives set in the original legislation, which included providing for a high level of environmental protection in the EU and contributing to reaching the EU's climate change targets, reducing oil consumption and thus improving the EU's energy security of supply, fostering innovation and the competitiveness of the European automotive industry and encouraging research into fuel efficiency technologies.

It concluded that the Regulations were still relevant, broadly coherent, and had generated significant emissions savings, while being more cost effective than originally anticipated for meeting the targets set. They also generated significant EU added value that could not have been achieved to the same extent through national measures. As regards impacts on competitiveness and innovation, the impacts of the Regulations were found to be generally positive.

Box 1 summarises the key outcomes in relation to the main evaluation criteria.

Box 1: Key conclusions of the report on the evaluation of Regulations (EC) No 443/2009 and (EU) No 510/2011 ('the Regulations')

Relevance

- The Regulations are still valid and will remain so for the period beyond 2020, as:
  - all sectors need to contribute to the fight against climate change,
  - the CO_2 performance of new vehicles needs to improve at a faster rate,
  - road transport needs to use less oil (to improve the security of energy supply), and
  - CO_2 reductions must be delivered cost-effectively without undermining either sustainable mobility or the competitiveness of the automotive industry.

Effectiveness

- The Regulations have been more successful in reducing CO_2 than previous voluntary agreements with industry (annual improvement rate of 3.4-4.8 gCO_2/km versus 1.1-1.9 gCO_2/km).
- The passenger car CO_2 Regulation is likely to have accounted for 65-85% of the reductions in tailpipe emissions achieved following its introduction. For light commercial vehicles (LCVs), the Regulation had an important role in speeding up emissions reductions.
- Impacts on competitiveness and innovation appear generally positive with no signs of competitive distortion.
- The evaluation report highlighted the following weaknesses:
  - The NEDC test cycle does not adequately reflect real-world emissions and there is an increasing discrepancy between test cycle and real-world emissions performance which has eroded the benefits of the Regulations.
  - The Regulations do not consider emissions due to the production of fuels or associated with vehicle production and disposal.
  - Some design elements (modalities) of the Regulations are likely to have had an impact on the efficiency of the Regulations. In particular, the use of mass as the utility parameter penalises the mass reduction as an emissions abatement option.

[19] Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles, available at: https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf

Efficiency

- The Regulations have generated net economic benefits to society.
- Costs to manufacturers have been much lower than originally anticipated as emissions abatement technologies have, in general, proved less costly than expected. For passenger cars, the ex-post average unit costs for meeting the target of 130gCO_2/km are estimated at €183 per car, while estimates prior to the introduction of the Regulation ranged from €430-984 per car. For LCVs the ex-post estimate to meet the 175gCO2/km was €115 per vehicle, compared with an ex ante estimate of €1,037 per vehicle.
- Lifetime fuel expenditure savings exceed upfront manufacturing costs, but have been lower than anticipated, primarily because of the increasing divergence between test cycle and real world emissions performance.

Coherence

- The Regulations are largely coherent internally and with each other.
- Modalities potentially weakening the Regulations, albeit with limited impacts, are the derogation for niche manufacturers, super-credits and the phase-in period (cars).

EU added value

- The harmonisation of the market is the most crucial aspect of EU added-value and it is unlikely that uncoordinated action would have been as efficient. The Regulations ensure common requirements, thus minimising costs for manufacturers, and provide regulatory certainty.

The evaluation report included some recommendations that would ensure the Regulations remain relevant, coherent, effective and efficient, including:

- With respect to relevance, a potential additional need to be considered for the post 2020 legislation is that road transport needs to use less energy. Hence, energy efficiency would become a more important metric as the LDV fleet moves to a more diverse mix of powertrains
- Concerning effectiveness, the most significant weakness identified was the current (NEDC) test cycle causing an increasing discrepancy between real-world and test cycle emissions, which has eroded a significant portion of the originally expected benefits of the Regulations. This will be largely addressed by the development of WLTP. In addition, sufficient checks are recommended to ensure that the new test does not in future years become subject to the same problems experienced with the NEDC.
- While the lack of consideration of the lifecycle and embedded emissions of vehicles was seen as a relatively minor issue, it was expected to become more significant as the proportion of electric vehicles increases.
- As regards additional incentives to develop low CO_2 emission vehicles, it should be considered whether such mechanism is needed and, if so, to choose one that does not potentially weaken the target.
- A need to look at how to improve the ex-ante assessment of costs to manufacturers as the costs assumed prior to the introduction of the current Regulations were much higher than has been the case in reality.

These recommendations are addressed when presenting the policy options in Section 5.

2 WHAT IS THE PROBLEM AND WHY IS IT A PROBLEM?

Figure 1 sets out the drivers, problems and objectives that are relevant for the revision of CO_2 standards for cars and vans.

While the revision will clearly contribute to all three policy objectives, it should also be clear that it does not aim to address all of the problems and drivers mentioned to the same extent. For this, complementary proposals and flanking measures will be taken, some of are scheduled to be part of the same package of mobility related initiatives. This concerns in particular the EU Action Plan on the Alternative Fuels Infrastructure Directive (limited infrastructure), the proposal for a revised Clean Vehicles Directive 2009/33/EC, as well as the proposal for a revised Directive on road charging ("Eurovignette").

The Commission is also preparing a proposal for setting CO_2 standards for heavy-duty vehicles, which would further help to tackle CO_2 emissions in the road transport sector.

Beside this, there are a number of areas where complementary Member State or local action would help to tackle the drivers and problems, e.g. through tax measures (in order to help lowering upfront costs, especially for zero- and low-emission vehicles), and measures promoting modal shift (i.e. lowering road transport activity.

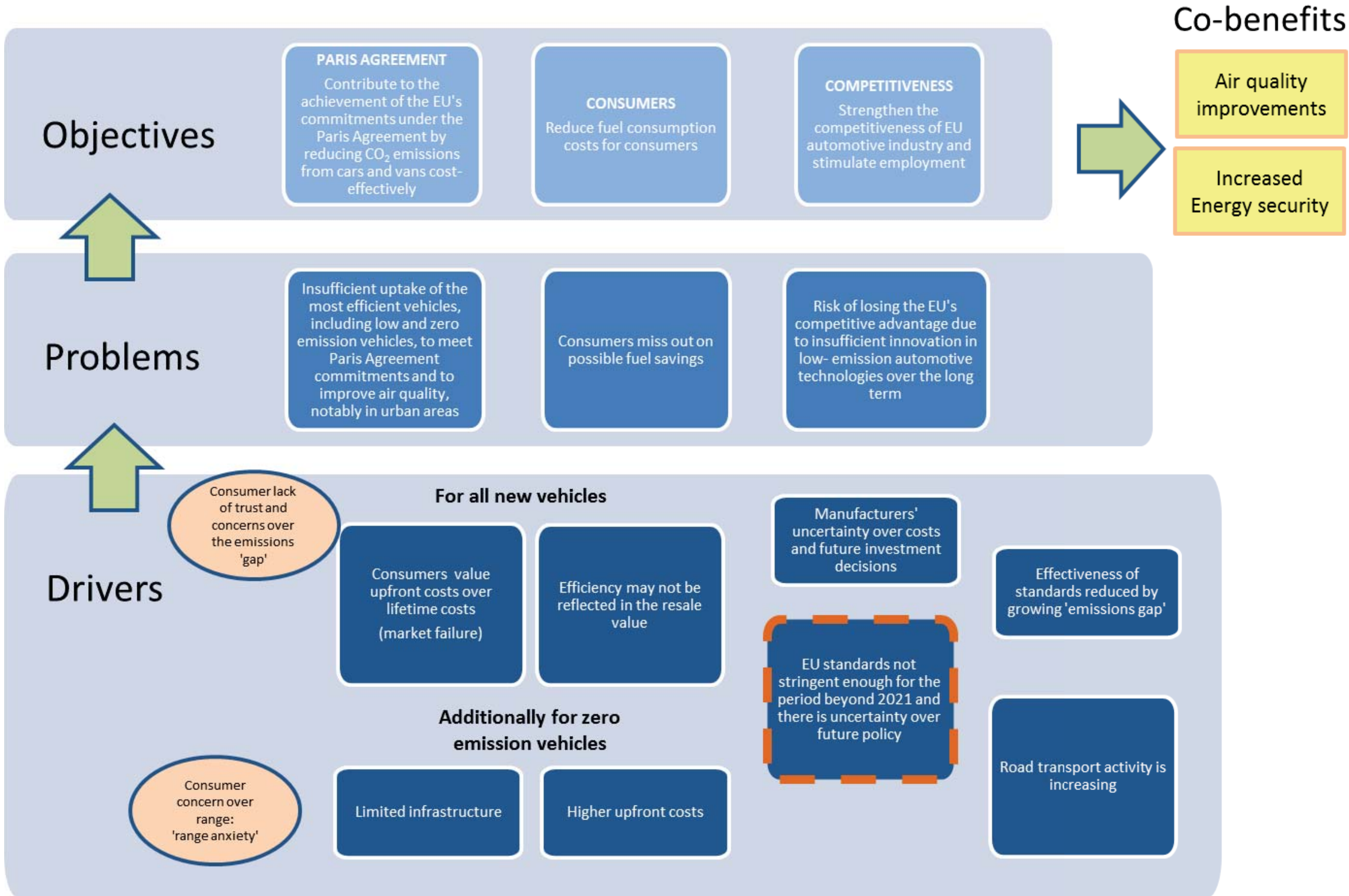
A key driver to be addressed by this impact assessment is the lack of stringency of the existing CO_2 standards for the period beyond 2021 and the related uncertainty over future standards. Other drivers are addressed to a different degree in the policy options set out in Section 5. Clarifying the policy framework beyond 2021 will help reducing manufacturers' uncertainty over costs and future investment decisions as well as tackling certain market failures. Creating a market demand for more efficient vehicles will also help to reduce upfront costs. In addition, the 'emissions gap' will be addressed.

By contrast, limited infrastructure and increasing transport activity are not directly tackled by the options considered in this impact assessment.

2.1 What is the nature of the problem? What is the size of the problem?

An overview of the problems and drivers is presented in Figure 2.

Figure 2: Drivers, problems and objectives



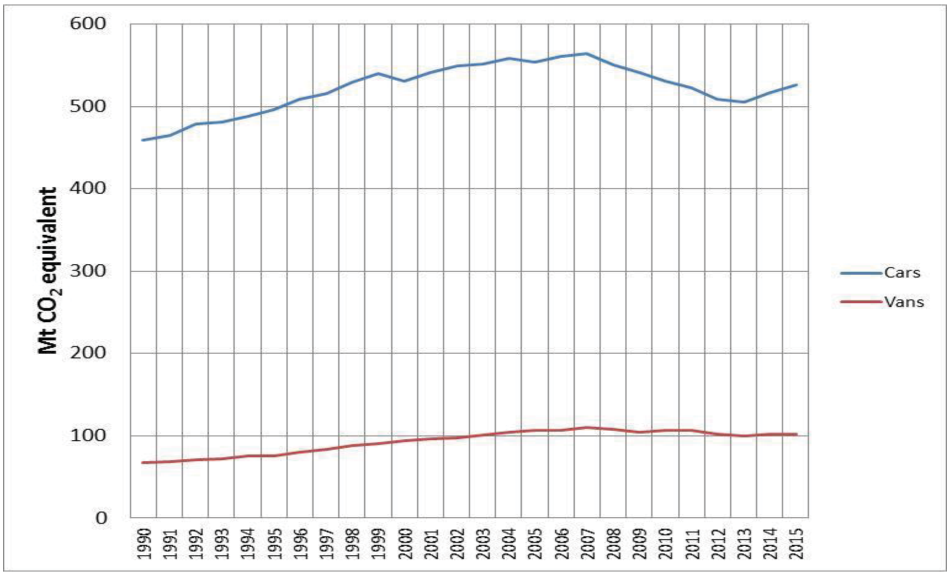
2.1.1 *Problem 1: Insufficient uptake of the most efficient vehicles, including low and zero emission vehicles, to meet Paris Agreement commitments and to improve air quality, notably in urban areas*

The evaluation of the CO_2 Regulations showed that the CO_2 standards have stimulated the uptake of more efficient vehicle technologies, but it also highlighted that the CO_2 performance of new vehicles needs to improve at a faster rate in order to achieve the Union's climate goals of at least 40% emissions reduction, as committed under the Paris Agreement, in a cost-effective way. As confirmed in the European Strategy for Low-Emission Mobility, greenhouse gas emissions from transport will need to be at least 60% lower than in 1990 and be firmly on the path towards zero.[20] With current trends in new vehicles' CO_2 emissions, this cannot be achieved. More specifically, the uptake of LEV and ZEV is still very slow. In 2016, battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) represented only 1.1% of the new EU car fleet (for BEV the share was only 0.41%).[21]

Road transport was responsible for 22%[22] of EU GHG emissions in 2015 with a steady increase since 1990 when the share was 13%. GHG emissions from cars and vans accounted for 73% of road transport emissions in 2015; this share has remained more or less constant since 1990.

Figure 3 shows that CO_2 emissions from cars and light commercial vehicles in 2015 were still 19% higher than in 1990, despite the decrease observed between 2007 and 2013. While the increase in the share of transport emissions of EU GHG emission may be due to the emissions reduction in other sectors, the evolution of GHG emissions from cars and vans shows a steady increase since 1990 with the exception of the period between 2007 and 2013 when emissions were reduced.

Figure 3: GHG emissions from cars and vans (1990-2015)[23]



[20] COM(2016) 501 final

[21] Final CO_2 monitoring data for 2015 (cars), http://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-11

[22] This share does not cover the emissions from international shipping, which are not part of the 2020 and 2030 climate and energy targets.

[23] EEA GHG data viewer (http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer), extracted on 01/09/2017

While the transport sector has considerably reduced its emissions of air pollutants in the EU over the last decades, it is the largest contributor to NO_x emissions (46% in total NO_x emissions in the EU in 2014). Of the total emitted NO_x from road transport, around 80% comes from diesel powered vehicles. In addition, the transport sector makes an important contribution to the concentration of particulate matter in the atmosphere (13% for PM_{10} and 15% for $PM_{2.5}$).[24]

EU air quality legislation[25] sets limit and target values for the concentration of a range of harmful air pollutants in ambient air in order to limit the exposure of citizens. Today, the limit values for NO_2 are being exceeded in over 130 cities across 23 Member States and the Commission has initiated legal action against 12 Member States.

The public debate on the announcement of possible "diesel bans" in some major cities has significantly affected the share of diesel vehicles in new car registrations. For instance, in March 2017 a 5-year low in new diesel car registrations was recorded in France, Germany, Spain, and the UK. These Member States represent together almost 60% of new car registrations in the EU.[26]

In the EU as a whole the share of diesel in new car registrations decreased from a peak of 53% in 2014 to 49% in 2016. At the same time the share of new petrol cars increased from 44% in 2014 to 47%. [27]

While urban access restrictions contribute to a shift from diesel to petrol with benefits in terms of lower air pollutant emissions, so far they have not triggered a significant increase in low- and zero-emission vehicles. Although new registrations of battery electric and plug-in hybrid vehicles increased by 46% by July 2017 compared to the same period in 2016, their share in total car registrations in the EU remains low at 1.2% of which 46% were battery electric vehicles[28].

A policy framework that further stimulates the accelerated uptake of zero- and low-emission vehicles would therefore complement the on-going efforts to address air quality problems and would be well aligned with on-going action at urban, regional, and national level. Zero-emission vehicles do not only deliver benefits in terms of air pollutant and noise emission free transport but also contribute to the reduction of CO_2 emissions from road transport.

2.1.2 Problem 2: Consumers miss out on possible fuel savings

In understanding potential fuel savings for consumers, including initial and subsequent vehicle purchasers it is important to understand that the current average lifetime of a car is around 15 years[29] with several ownership changes. Consumers have benefitted from

---

[24] EEA (2016): Air quality in Europe - 2016 report. EEA Report No 28/2016,

[25] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe, OJ L 152, 11.6.2008, p. 1.

[26] ICCT (2017): Cities driving diesel out of the European car market, http://www.theicct.org/blogs/staff/cities-driving-diesel-out-european-car-market

[27] Monitoring of CO_2 emissions from passenger cars – Regulation 443/2009: https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-12/#parentfieldname-title

[28] European Alternative Fuels Observatory, http://www.eafo.eu/eu#eu_pev_mark_shr_graph_anchor

[29] Ricardo-AEA (2015): Improvements to the definition of lifetime mileage of light duty vehicles, (https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/ldv_mileage_improvement_en.pdf). Cars in the European Union are on average 9.7 years old: http://www.acea.be/statistics/tag/category/average-vehicle-age

net savings over a vehicle's lifetime, although relatively few consumers consider fuel consumption when purchasing a new car[30].

So far the increases in the purchase prices of more efficient vehicles, as a result of the CO_2 standards, have been significantly lower than the fuel savings over the vehicle's lifetime.

According to the evaluation of the CO_2 Regulations the additional purchase cost of a new car in 2013 was €183 higher compared with a 2006 vehicle due to measures to meet the CO_2 standards. At the same time (discounted) fuel savings, as a result of the CO_2 standards, were €1,336 for petrol cars and €981 for diesel cars over the vehicle's lifetime. Lifetime fuel expenditure savings have been lower than anticipated, primarily because of the increasing divergence between test cycle and real world emissions performance. However, even if this gap were to be reduced significantly by the introduction of the WLTP test cycle and additional governance measures (see section 5.5), there remains an important unused cost savings potential. If this potential were to be exploited through more stringent CO_2 standards, consumers could benefit from even higher fuel savings. The savings are however spread differently across the vehicle's lifetime.

An analysis of second hand car and van markets and implications for the cost effectiveness and social equity of light-duty vehicles CO_2 regulations[31] shows that subsequent owners of a vehicle, who on average belong to lower income groups, proportionally benefit more from fuels saving than first vehicle owners. The initial cost for the more efficient vehicle is borne by the first owner. This depends however strongly on the initial price premium for the more efficient vehicle.

2.1.3 Problem 3: Risk of losing the EU's competitive advantage due to insufficient innovation in low- emission automotive technologies over the long term

The EU automotive sector is crucial to the EU economy, including in terms of the number of direct and indirect jobs it provides. It faces global competition in terms of sales to other markets and, increasingly, from non-EU manufacturers within the EU market. The import of motor vehicles to the EU has increased from 2.5 million vehicles in 2010 to 3.4 million motor vehicles in 2016, worth € 45.7 billion.[32]

The competitiveness of industry is also related to its capacity to innovate. Looking at the relationship between the regulatory standards and industrial innovation, the Evaluation study found that EU fuel efficiency standards for new cars and vans have proven to be a strong driver for innovation and efficiency in automotive technology.[33] These targets allowed the EU manufacturers to have a first mover competitive advantage which has

---

[30] Eurobarometer survey on climate change in 2017 shows that fewer than one in ten citizens (9%) have bought a new car partly for its low fuel consumption, down from 13% in 2015. (https://ec.europa.eu/clima/news/eu-citizens-increasingly-concerned-about-climate-change-and-see-economic-benefits-taking-action_en)

[31] TM Leuven (2016): Data gathering and analysis to improve the understanding of 2nd hand car and LDV markets and implications for the cost effectiveness and social equity of LDV CO_2 regulations. Final Report, https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/2nd_hand_cars_en.pdf

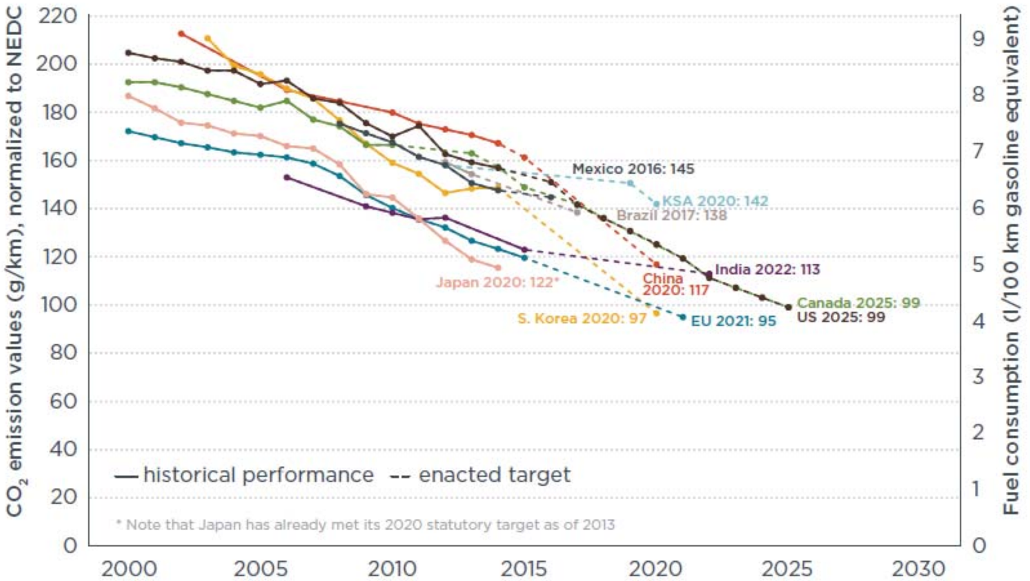
[32] ACEA (2017): Imports of Motor Vehicles, http://www.acea.be/statistics/tag/category/imports-of-motor-vehicles (accessed 23 June 2017)

[33] Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles

been especially important as the EU automotive industry exported more than 6 million vehicles in 2016, worth €135 billion.[34]

However, as shown in Figure 4, different fuel standards have progressively been implemented around the world, in countries including China, USA, South Korea, Mexico, Brazil and India. These international targets, moving over time towards the levels set in the EU, and coupled with the commitments made on climate change targets under the 2015 Paris Agreement, demonstrate the international demand for efficient vehicles.

Figure 4: Historical fleet CO_2 emissions performance and current standards (gCO_2/km normalized to NEDC) for passenger cars[35] (ICCT, 2017)



Major non-EU car markets have considered or are about to introduce more ambitious policies including measures to reduce pollutant emissions. In particular, in view of increasing the deployment of zero- and low emission vehicles, ambitious policies have been developed or recently adopted in car markets that are of particular importance for the EU car industry. In the US, the Californian "ZEV" standards to support the market deployment of battery electric, plug-in hybrid, and fuel cell vehicles have also been adopted by nine other States (29% of all new cars sold in the U.S. are sold in these 10 States) (see Box 2 for more details).[36] Eight US States have signed a memorandum of understanding committing to coordinated action to ensure that by 2025 at least 3.3 million pure battery electric vehicles, plug-in hybrid electric vehicles and hydrogen fuel cell electric vehicles are on their roads.[37]

[34] ACEA (2017): Exports of Motor Vehicles, http://www.acea.be/statistics/tag/category/exports-of-motor-vehicles (accessed 23 June 2017)

[35] ICCT (2017): 2017 Global update light-duty vehicle greenhouse gas and fuel economy standards, http://www.theicct.org/sites/default/files/publications/2017-Global-LDV-Standards-Update_ICCT-Report_23062017_vF.pdf, p. 10

[36] CARB (2017): California's Advanced Clean Cars Midterm Review - Summary Report for the Technical Analysis of the Light Duty Vehicle Standards, https://www.arb.ca.gov/msprog/acc/mtr/acc_mtr_summaryreport.pdf

[37] https://www.zevstates.us/

In China, new mandatory "new energy vehicle" (NEV) requirements will apply to car manufacturers as from 2019 covering battery electric, plug-in hybrid, and fuel cell vehicles (see Box 3 for more details).[38] The requirements are applicable to all manufacturers with an annual production or import volume of 30,000 or more conventional fuel passenger cars.

Over the last decade China has become the key car market with 24 million new car registrations, meaning that every third new vehicle is now being sold in China. European car manufacturers have been successful in reaching out to this new market. More than 20% of new passenger cars sold in China were from European car manufacturers/joint ventures operating in China. One third of global sales by German manufacturers, i.e. around 15 million vehicles, took place in China: 39% for the VW Group and 22% for the BMW Group and Mercedes Benz Cars[39]. Similarly, China is the most important car market for the PSA Group with more than 600,000 vehicles sold[40].

A recent analysis of seven global automotive lead markets concludes that China is now in the "pole position" and will dominate the increasing market for electrified powertrains for the foreseeable future due to the importance of the Chinese market and a favourable regulatory framework.[41]

While Japan alone accounts for 40% of EV related patents, the EU automotive industry is the global leader in automotive patents in general.[42] At the same time patents data show that parts of the European car industry have a strong technological potential in LEV/ZEV which are however not sufficiently reflected in new products offered on the European market.[43]

This indicates that the EU industry risks losing its technological leadership and lagging behind these global trends.

2.2 What are the main drivers?

2.2.1 Driver 1: Consumers value upfront costs over lifetime costs

There are a number of market failures and barriers[44] which cause end-users to not necessarily purchase the most efficient new vehicles available on the market, even where

[38] http://www.miit.gov.cn/n1146295/n1146557/n1146624/c5824932/content.html

[39] EY (2017): Der Pkw-Absatzmarkt China 2009 bis 2016, http://www.ey.com/Publication/vwLUAssets/ey-auto-absatzmarkt-china-2017/$FILE/ey-auto-absatzmarkt-china-2017.pdf

[40] PSA Group (2017): Chine et Asie du Sud-Est, https://www.groupe-psa.com/fr/groupe-automobile/presence-internationale/chine-asie-sud-est/

[41] Roland Berger, Forschungsgesellschaft Kraftfahrwesen mbH Aachen (2017): Study E-mobility Index Q2 2017, June 2017, https://www.fka.de/consulting/studien/e-mobility-index-2017-q2-e.pdf (accessed 18/06/2017)

[42] ACEA (2017): Decarbonisation of transport – impact on jobs. Stakeholder Meeting organised by the European Commission, DG CLIMA, 26 June 2017, Brussels.

[43] Falck, O. et al. (2017): "Auswirkungen eines Zulassungsverbots für Personenkraftwagen und leichte Nutzfahrzeuge mit Verbrennungsmotoren" ifo Institut, http://www.cesifo-group.de/portal/page/portal/DocBase_Service/studien/Studie-2017-Falck-etal-Zulassungsverbot-Verbrennungsmotoren.pdf

[44] See e.g.: 'Mind the Gap, Quantifying Principle-Agent Problems in Energy Efficiency', IEA, https://www.iea.org/publications/freepublications/publication/mind_the_gap.pdf'; 'Market failures and barriers as a basis for clean energy policies', Marilyn A Brown, Energy Policy volume 29, issue 14, Nov 2001, pp 1197-1207; Greene, David (2010) Why the market for new passenger cars generally

this would be their optimal choice from an economic perspective, i.e. when the fuel economy benefit outweighs the additional costs for a more efficient vehicle.

When purchasing a new car, end-users tend to undervalue future fuel savings as a result of which it may not appear attractive to pay more for a more efficient vehicle. This is for instance empirically evidenced by the results of the evaluation of the CO_2 Regulations, which show that fuel savings are significantly higher than the additional purchase cost of a new car (see Section 1.3). Despite existing fuel taxes, these clear financial benefits were apparently not reaped by the market, but required specific regulation to tap into such economic benefits.

Furthermore, even if the new vehicle purchasers do take account of fuel savings, it would only be rational for them to consider fuel savings for the period in which they intend to own the vehicle. As vehicles have an average lifetime of about 15 years with 4 owners, only a part of the reductions would be experienced by the initial purchaser.

In addition, a wide range of factors and elements other than fuel economy may dominate the purchase decision of a new car. Purchasers of new cars have skewed preferences away from fuel economy and towards factors such as comfort and power.[45] Another reason for the apparently economically suboptimal uptake of more efficient vehicles therefore lies on the production side. In a highly competitive automotive market, manufacturers may be hesitant to invest heavily in more efficient powertrains, knowing that competitors may have different commercial strategies (focusing on other vehicle attributes such as higher engine capacity, more comfort, etc.) that could be commercially more successful. This is in particular the case if consumers pay little attention to total cost of ownership. A regulatory framework on CO_2 emissions for all new vehicles takes away the competitive risk that a manufacturer would be facing when focusing innovation efforts on fuel efficiency, while others do not.

Different purchase dynamics may apply for leased vehicles which have a share of around 30% of new registrations in the EU, with most of them being company cars. Leasing could in principle increase the attractiveness of lower CO_2 vehicles, on the one hand by enabling instant payback on fuel saving 'investments', and on the other by helping operators optimise vehicle choice by enabling them to better take into account the costs and benefits associated with lower CO_2 vehicles in the context of CO_2-based national vehicle taxation schemes. However, the extent to which these factors affect the uptake of lower CO_2 vehicles in practice could not be quantified due to a current lack of evidence.[46]

---

undervalues fuel economy, OECD/ITF Joint Transport Research Centre Discussion Paper, No. 2010-6 (http://dx.doi.org/10.1787/5kmjp68qtm6f-en)

[45] CAP HPI Consulting (2016): A study into the fitment and pricing of optional extras onto new motor vehicles in the UK and their resale in the used market. https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/uk_automotive_study_en.pdf

[46] Ricardo Energy & Environment (2016): Consideration of light duty vehicle leasing in relation to the cost effectiveness of LDV CO_2 regulation. (https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/ldv_leasing_en.pdf): "In France and the UK, leased vehicles across most segments and fuel types have significantly lower CO_2 emissions ratings than the average new vehicle. However, it is not clear how non-leased company cars perform in comparison and so it is difficult to draw conclusions. "

2.2.2 *Driver 2: Consumers' concerns regarding zero emission vehicles (ZEV)*

Beyond the issue of undervaluing future benefits from fuel savings, the limited market uptake of ZEV is strongly influenced by additional factors. ZEV (battery EV and fuel cell EV) are still faced with much higher upfront costs[47] as compared to conventional vehicles.[48]

Consumers are also concerned about other issues regarding ZEV. As demonstrated in research[49], a major barrier is consumer resistance to new technologies that are considered alien or unproved. As other barriers perceived by the consumers, the study mentioned battery range, charging infrastructure, reliability, safety. Furthermore, the perceived limited comfort and style were seen as limiting the attractiveness of available ZEV models.

A key barrier is 'range anxiety', i.e. the perception that the battery capacity is limited and recharging infrastructure is insufficient to ensure recharging 'on time' and at the necessary recharging speed in particular for long-distance trips. This is underlined by the fact that the electric range for the most sold battery electric vehicles in the EU is currently between 150 and 250 km.

Despite important progress and sufficient coverage in most Member States given the low uptake of ZEV so far, the infrastructure for recharging ZEV is insufficient in many Member States in particular in view of the expected uptake of ZEVs by 2020 and beyond[50]. The Commission's Communication, 'Europe on the Move: An agenda for a socially fair transition towards clean, competitive and connected mobility for all' underlines that the deployment of a network of recharging points covering evenly the whole EU road network, is a key enabling condition for zero-emission mobility. The Action Plan on the Alternative Fuels Infrastructure Directive sets out concrete measures for achieving necessary deployment rates[51]. Experience from other regions shows that with an increase in the number of electric vehicles sold investments in the necessary infrastructure increases as well. Besides, reinforced support for research and development of batteries will be provided by Horizon 2020 in the context of the new working programme 2018-2020.

---

[47] ICCT (2016): Electric vehicles: Literature review of technology costs and carbon emissions, Working Paper 2016-14, http://www.theicct.org/sites/default/files/publications/ICCT_LitRvw_EV-tech-costs_201607.pdf

[48] Some studies have suggested that convergence of total cost of ownership for some ZEV may occur by 2020, see, for example_Element Energy (2016): Low carbon cars in the 2020s. Consumer impacts and EU policy implications, http://www.beuc.eu/publications/beuc-x-2016-121_low_carbon_cars_in_the_2020s-report.pdf (04/05/2017)

[49] Egbue, O.l Long, S. (2012): Barriers to wide spread adoption of electric vehicles: An analysis of consumer attitudes and perceptions, Energy Policy, Vol. 48, p. 717–729, http://dx.doi.org/10.1016/j.enpol.2012.06.009

[50] Commission Staff Working Document (2017), Detailed Assessment of National Policy Frameworks under Directive 2014/94/EU.

[51] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks unde rARticle 10(2) of Directive 2014/94/EU.

Another concern among consumers is linked to the resale value of ZEV given expected further technical improvements in particular on the battery's performance (range, lifetime, costs).[52]

At the same, the market for ZEV is developing rapidly. New technologies and business models may help to overcome some of the barriers discussed above. For example, new ZEV in the compact car segment are offered in Europe with ranges of up to 380 km[53]. Some ZEV are offered with a lease contract for the battery[54] which lowers upfront costs and can address possible consumer concerns related to the battery technology.

In this context, it should be noted that consumer research in the US and Germany showed that a large share of prospective new vehicle buyers (29% in the US, 44% in Germany) would consider purchasing a battery electric vehicle (BEV) or a plug-in hybrid electric vehicle (PHEV), which indicates a substantial latent demand for such vehicles. However, it was also found that half of all consumers are not yet familiar with electric vehicles. The researchers conclude that there is an opportunity for manufacturers to quickly increase the number of potential buyers by offering more tailored EVs and deploying new business models[55]. A JRC study covering six EU Member States[56] concluded in 2012 that on average around 40% of the car drivers surveyed would consider buying an electric car when changing their current vehicle[57].

2.2.3 Driver 3: EU standards do not provide enough incentive for further efficiency improvements and for the deployment of low and zero emission vehicles for the period beyond 2021, leading to uncertainty over future policy

The current Regulations for cars and vans set targets of 95 g CO_2/km for 2021 and 147 g CO_2/km for 2020 respectively. In the absence of new legislation, these targets will remain at their present levels. As the current targets can be largely met by improving conventional vehicles, they do not provide sufficient incentive to invest in and in particular market alternative powertrains, in particular ZEV.

As a consequence there is insufficient uptake of LEVs and ZEVs in the EU as a result of which the necessary GHG emission reductions in the road transport sector cannot be achieved. Given persisting market failures (see Driver 1) under these conditions manufacturers are not likely to develop, produce and offer more efficient vehicles for the EU market at sufficient scale. The EU automotive industry therefore risks losing leadership in low-emission technologies for road transport.

---

[52] European Environment Agency (2016): Electric vehicles in Europe, EEA Report No 20/2016

[53] The new Opel Ampera-e has an electric range of 380 km (WLTP) and 520 km (NEDC), source: http://media.opel.com/media/intl/en/opel/vehicles/ampera-e/2017.detail.html/content/Pages/presskits/intl/en/2017/opel/04-21-ampera-e-new-way-of-driving.html

[54] Renault offers the new ZOE with a lease contract for the battery, source: https://fr.renault.be/vehicules/vehicules-electriques/zoe.html.

[55] McKinsey&Company (2017) Electrifying insights: How automakers can drive electrified vehicle sales and profitability (http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-insights-how-automakers-can-drive-electrified-vehicle-sales-and-profitability)

[56] France, Germany, Italy, Poland, Spain, United Kingdom

[57] Thiel, C., Alemanno, A., Scarcella, G, Zubaryeva, A., Pasaoglu, K. (2012): Attitude of European car drivers towards electric vehicles: a survey, http://publications.jrc.ec.europa.eu/repository/handle/JRC76867

As long as the automotive industry, including manufacturers and suppliers, does not know what will happen to targets beyond 2020/2021 and whether any additional requirements will be put in place, they do not have the regulatory certainty required to invest with confidence for the EU market. Without clarity on the long-term regulatory framework companies cannot take long-term investment decisions in order to meet future market demands and optimise compliance costs.

2.2.4 Driver 4: Effectiveness of standards is reduced by growing 'emissions gap'

There is evidence of an increasing divergence between average test and real world CO_2 emissions. Recent studies estimate the divergence is up to around 40%[58]. A number of factors have been identified to explain the divergence including the deployment of CO_2 reducing technologies delivering more savings under test conditions than on the road, the optimisation of the test procedure as well as the increased deployment of energy using devices which are not taken into account when a vehicle is tested for its certified CO_2 emissions. For example, air conditioning systems are not included when a vehicle is tested for its certified CO_2 emissions but are widely installed and used, thus leading to higher real world emissions.

This increasing divergence means that the actual CO_2 savings achieved are considerably less than those suggested by the test performance. Since manufacturers' compliance with their specific emissions target is assessed on the basis of the CO_2 emissions as certified during the official test cycle, the 'emissions gap' undermines the effectiveness of the CO_2 performance standards. In addition, the 'emissions gap' has undermined consumers' trust in the potential CO_2/fuel savings of new vehicles which in turn may have affected consumers' willingness to buy the most efficient vehicles.

2.2.5 Driver 5: Road transport activity is increasing

EU transport activity is expected to continue growing under current trends and adopted policies, albeit at a slower pace than in the past[59]. Despite profound shifts in mobility being underway, such as shared mobility services and easier shifts between modes, passenger traffic growth is still projected to increase 23% by 2030 (1% per year) and 42% by 2050 (0.9% per year) relative to 2010. Road transport would maintain its dominant role within the EU. Passenger cars and vans would still contribute 70% of passenger traffic by 2030 and about two thirds by 2050, despite growing at lower pace relative to other modes due to slowdown in car ownership increase.

While this increased activity is reflective of economic growth, it brings with it negative impacts in terms of GHG emissions and air quality impacts, if no additional measures are taken. It remains to be seen to what extent other developments such as autonomous driving may affect road transport activity.

---

[58] Scientific Advice Mechanism (SAM) (2016): Closing the gap between light-duty vehicle real-world CO2 emissions and laboratory testing, High Level Group of Scientific Advisors, Scientific Opinion 01, Brussels, 11 November 2016; Zacharof, N., Fontaras, G., Ciuffo, B., Tsiakmakis, S. et al. (2016) Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars (EUR 27819 EN; doi:10.2790/140640)

[59] Impact Assessment accompanying the Proposal for a Directive of the European Parliament and of the Council amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures and Proposal for a Council Directive amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, as regards certain provisions on vehicle taxation, Commission Staff Working Document, SWD(2017) 180 final.

2.3 Who is affected and how?

The users of vehicles, both individuals and businesses, are affected because they face the cost of the energy required to propel the vehicles. Reducing the vehicle's CO_2 emissions will reduce the energy required and result in a cost saving to the user. The use of technology to reduce in-use GHG emissions has a cost which is expected to be passed on to the vehicle purchaser.

Citizens, especially those living in urban areas with high concentrations of pollutants, will benefit from better air quality and less associated health problems due to reduced air pollutant emissions, in particular when the uptake of zero-emission vehicles increases.

CO_2 standards require vehicle manufacturers to reduce CO_2 emissions as a result of which they will have to introduce technical CO_2 reduction measures. In the short-term, this is likely to result in increased production costs and could affect the structure of their product portfolios. However, demand for low- and zero-emission CO_2 vehicles is expected to increase throughout the world as climate change and air quality policies develop and other countries introduce similar or even more ambitious standards, manufacturers have an opportunity to gain first mover advantage and the potential to sell advanced low CO_2 vehicles in other markets.

Suppliers of components and materials from which vehicles are constructed will be affected by changing demands on them. Component suppliers have a key role in researching and developing technologies and marketing them to vehicle manufacturers. Requirements leading to the uptake of additional technologies or materials (e.g. aluminium, plastics, advanced construction materials) may create extra business activity for them. While often overlooked, EU employment in the component supply industry is as large as in the vehicle manufacturing industry.

Suppliers of fuels are affected by reduced energy demand leading to less utilisation of existing infrastructure. If demand shifts to vehicles supplied with alternative energy sources, this may potentially increase the need for other types of infrastructure and create new business opportunities and challenges for electricity supply companies and network operators.

There may also be impacts for example in the need for or type of vehicle servicing. There will also be lower maintenance requirements for battery electric vehicles.

The production and maintenance of vehicles with an electrified powertrain will pose important 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 to deal with new components and manufacturing processes.

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.

3 WHY SHOULD THE EU ACT?

3.1 The EU's right to act

The Environment chapter of the Treaty, in particular Article 191 and Article 192 of TFEU, give the EU the right to act in order to guarantee a high level of environmental protection. As mentioned in Section 1.1, based on Article 192 TFEU, the EU has already acted in the area of vehicle emissions, including adopting Regulations (EC) 443/2009 and (EU) 510/2011 which set limits for CO_2 emissions from cars and vans, and with implementing legislation on monitoring and reporting of data (Commission Regulation (EU) No 1014/2010 (cars) and Commission Implementing Regulation 2012/293/EU (vans)).

3.2 What would happen without EU action?

EU fuel efficiency standards for new cars and vans have proven to be a strong driver for innovation and efficiency in automotive technology. These targets allowed EU manufacturers to have a first mover advantage and to increase exports globally. Without further action in this field, it will be difficult for the EU automotive sector to retain its leading role in global markets as developing innovation and cutting-edge technologies is the only way to maintain and strengthen European competitiveness.

With all major markets with the exception of China and India projected to stall in the future, it will be important for the EU to maintain or increase the share of high-quality and high-technology vehicles on third markets, notably in those markets that are likely to grow fast. (source GEAR 2030)

Besides, without further EU action in this field it is likely there would be little additional substantial CO_2 reduction from new light-duty vehicles. There may be certain expectations that in view of the current CO_2 requirements and expected regulatory action in this field in third countries to which European vehicles are exported, the fuel efficiency improvement of vehicles may continue somewhat beyond this rate. However, as seen in the EU in the period between 1995 and 2006 for cars, in the absence of the mandatory CO_2 standard this progress is likely to be offset at least to some degree by the increase in power, size or comfort of new cars.

Some reduction in emissions from the overall fleet of light-duty vehicles would still be expected beyond 2021 due to the continuing renewal of the existing fleet with newer cars and vans meeting the 2020/21 CO_2 standards. However, transport activity would continue to increase and the overall CO_2 reductions would not be sufficient to reach the targets set by the European Council in the 2030 Climate and Energy Package or contribute sufficiently to the goals of the Paris Agreement.

3.3 Analysis of subsidiarity and added value of EU action

EU action is justified in view of both the cross-border impact of climate change and the need to safeguard single markets in vehicles.

Without EU level action there would be a risk of a range of national schemes to reduce light duty vehicle CO_2 emissions. If this were to happen it would result in differing ambition levels and design parameters which would require a range of technology options and vehicle configurations, diminishing economies of scale.

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 is even a risk that national legislation might be tailored to suit local industry.

This poor coordination of requirements between countries, even if all Member States were to establish regulatory requirements for new vehicle CO_2 emissions, would raise compliance costs for manufacturers as well as weaken the incentive to design fuel efficient cars and LCVs because of the fragmentation of the European market. 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 cars across the EU. This means that greater benefits will be achieved for the same cost from coordinated EU action than would be achieved from differing levels of Member State action.

With action only at Member State level we would not benefit from the lower costs which would arise as a result of the economies of scale that an EU wide policy delivers. The EU light vehicle market is currently around 16 million vehicles per year. The largest Member State market is around 3 million vehicles per year. On their own, individual Member States would represent too small a market to achieve the same level of results and therefore an EU wide approach is needed to drive industry level changes.

The additional costs which would arise from the lack of common standards and common technical solutions or vehicle configurations would be incurred by both component suppliers and vehicle manufacturers. However, they ultimately would be passed on to consumers who would face higher vehicle costs for the same level of greenhouse gas reduction without coordinated EU action.

The automotive industry requires as much regulatory certainty as possible if it is to make the large capital investments necessary to maximise the fuel economy of new vehicles, and even more so for shifting to new primary energy sources. Standards provide this certainty over a long planning horizon and they could not be implemented with the same effectiveness and certainty at Member State level.

4 OBJECTIVES

General policy objective

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

Specific objectives

1. Contribute to the achievement of the EU's commitments under the **Paris Agreement** by reducing CO_2 emissions from cars and vans cost-effectively;
2. Reduce fuel consumption costs for **consumers**;
3. Strengthen the **competitiveness** of EU automotive industry and stimulate employment.

These three specific objectives are on equal footing.

The first one concerns the climate objective of the **Paris Agreement**. Further efforts are necessary for all Member States to meet their 2030 targets under the Effort Sharing Regulation. With road transport causing one third of non-ETS emissions and emissions increasing in the last few years, reducing CO_2 emissions from cars and vans is of key importance.

Implementing the Paris Agreement requires the decarbonisation of the economy including of road transport. The Low-Emission Mobility Strategy has confirmed the ambition of reducing GHG emissions from transport by at least 60% by 2050, as initially set out in the 2011 Low-Carbon Economy Roadmap and Transport White Paper.

This cannot happen without a very high deployment of zero- and low-emission vehicles. Analysis has shown that by 2050, electrically chargeable vehicles need to represent about 68-72% of all light duty vehicles on the roads. This requires a significantly increasing uptake of zero- and low-emission vehicles already in 2030 as the new vehicles of 2030 will remain on the road until the mid-2040s.

The second specific objective is related to the **consumer** angle of the CO_2 standards, aiming to create benefits for car and van users through the sales of more efficient vehicles.

The third specific objective relates to innovation, **competitiveness** (including fair competition amongst EU manufacturers) and employment. While the EU automotive sector has been very successful in advanced internal combustion engine vehicles world-wide, it will need to adapt to the ongoing global transitions in the area of mobility and transport in order to maintain its technological leadership.

By providing a clear regulatory signal and predictability for industry to develop and invest in zero- and low-emission vehicles and fuel-efficient technologies, this initiative aims to foster innovation and strengthen EU industry's competitiveness in a fast changing global automotive landscape, without distorting the competition between EU manufacturers.

In addition to the three abovementioned specific objectives, the revision of the CO_2 standards for cars and vans are 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?

This Section describes the options identified to address the problems listed in Section 3 and to achieve the objectives defined in Section 4. It sets out the rationale for their selection, as well as the reasons for discarding certain options upfront, taking into account the evaluation study, the public consultation, additional stakeholder input; as well as several internal and external study reports. The options cover a number of elements, some of which are already part of the current Regulations. The options are grouped into five categories:

(i) CO_2 emission targets (level, timing, metric);

(ii) the distribution of effort amongst manufacturers;

(iii) incentives for low- and zero-emission vehicles;

(iv) elements for cost-effective implementation;

(v) governance related issues

The following tables show how the policy options, grouped into the five key policy areas, relate to the problems and objectives

Table 2: Policy options and problems

Key policy areas	**Problem 1:** Insufficient uptake of the most efficient vehicles, including low and zero emission vehicles, to meet Paris Agreement commitments and to improve air quality, notably in urban areas	**Problem 2:** Consumers miss out on possible fuel savings (market failures)	**Problem 3:** Risk of losing the EU's competitive advantage due to insufficient innovation in low-emission automotive technologies over the long term
Emission targets	✓	✓	✓
Distribution of effort			✓
ZEV/ LEV incentives	✓	✓	✓
Elements for cost-effective implementation			✓
Governance	✓	✓	

Table 3: Policy options and objectives

Key policy areas	**PARIS AGREEMENT:** Contribute to the achievement of the EU's commitments under the Paris Agreement Reduce by reducing CO2 emissions from cars and vans cost-effectively	**CONSUMERS:** Reduce fuel consumption costs for consumers	**COMPETITIVENESS:** Strengthen the competitiveness of EU automotive industry and stimulate employment
Emission targets	✓	✓	✓
Distribution of effort			✓
ZEV/ LEV incentives	✓	✓	✓
Elements for cost-effective implementation	✓		✓
Governance	✓	✓	

5.1 Emission targets (level, timing and metric)

The currently applicable Regulations (EC) No 443/2009 ("Cars Regulation") and (EU) No 510/2011 ("Vans Regulation") set a fleet-wide target of 95 g CO_2/km (from 2021, with a phase-in from 2020) and 147 g CO_2/km (from 2020), respectively, for the emissions of newly registered vehicles. These targets are based on the NEDC test procedure. Compared to the targets set previously, they represent an average annual reduction of 5.1% for cars (from the 2015 target of 130 g CO_2/km) and of 5.6% for vans (from the 2017 target of 175 g CO_2/km).

The introduction of the new test procedure WLTP, in September 2017[60], is expected to bring the tailpipe CO_2 emissions from cars and vans determined during type approval closer to the real world emissions. The WLTP will be fully applicable to all new cars and vans from September 2019 (see also Section 5.5).

WLTP is likely to result in increased CO_2 emissions for most vehicles but the increase will not be evenly distributed between different manufacturers. Due to this non-linear relationship between the CO_2 emission test results from the NEDC and WLTP test-procedures, it is impossible to determine one single factor to correlate NEDC into WLTP CO_2 emission values. A correlation procedure[61] will therefore be performed at the level of individual manufacturer. Based on the correlation procedures and the methodology adopted for translating the individual manufacturer targets from NEDC to WLTP values,

[60] Commission Regulation (EU) 2017/1151 of 1 June 2017 supplementing Regulation (EC) No 715/2007

[61] Commission Implementing Regulation (EU) 2017/1153; Commission Implementing Regulation (EU) 2017/1152

WLTP-based manufacturer targets will apply from 2021 onwards. Those targets will be confirmed by the Commission and published in October 2022.[62]

More information on the transition from NEDC to WLTP is given in Annex 5.

5.1.1 CO_2 emission target level (TL)

The likely increase in WLTP CO_2 emission values (compared to NEDC) has been taken into account for the purposes of the analytical work underlying this impact assessment (see Annex 4.6).

Since the exact specific WLTP emission target values for 2021 can only be determined in 2022 (as described above), the new emission targets should be defined not as absolute values but in relative terms. The starting point for this are the 2021 EU-wide fleet average WLTP emission targets (i.e. the weighted average of the manufacturers' specific emissions targets for 2021). The new targets can be expressed either as a percentage reduction of those 2021 EU-wide fleet targets or as an average annual reduction rate over a given period.

The options in this section for the new EU-wide fleet average target levels ("TLC" for cars and "TLV" for vans) are defining the target trajectory over the period 2021-2030, without prejudging the target years. Options as regards the timing of the targets are set out in Section 5.1.2.

5.1.1.1 CO_2 target level for passenger cars (TLC)

- Option TLC0: Change nothing (baseline)

  This option represents the status quo, meaning that the CO_2 target level set in the current Regulation is maintained after 2021 (WLTP equivalent of 95 g CO_2/km as EU-wide fleet average).

- The other options for defining the EU-wide fleet CO_2 target level for passenger cars are summarised in the below table.

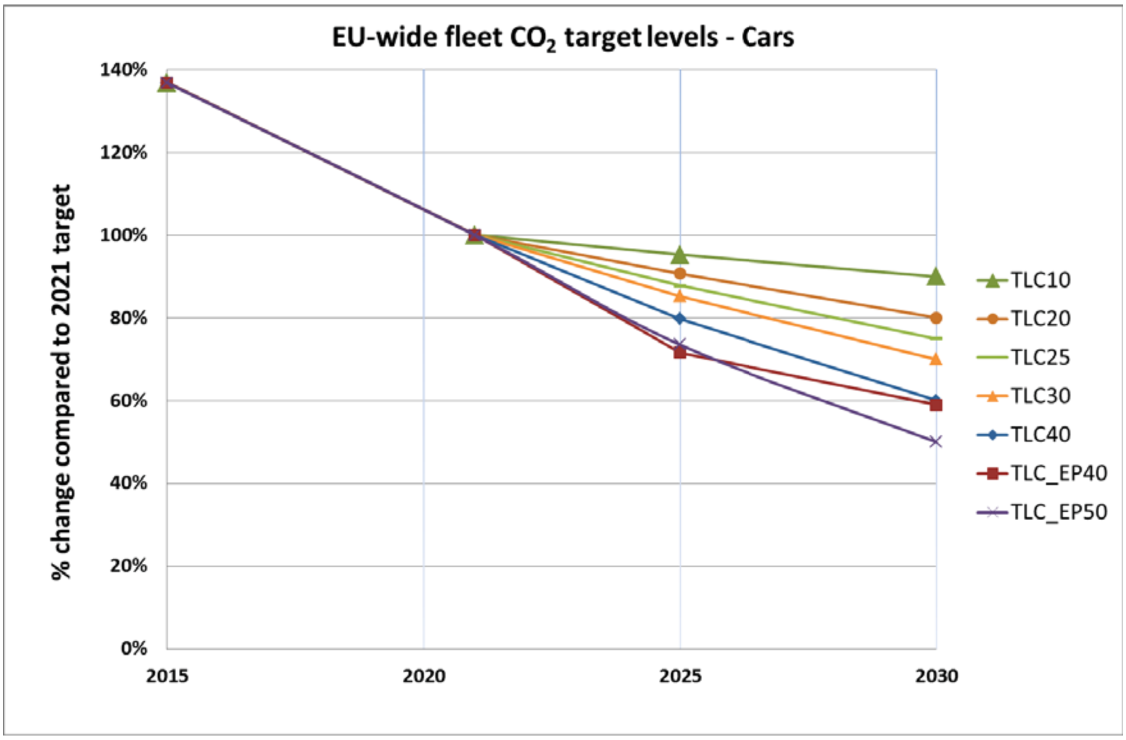
Option	Decrease of WLTP CO_2 target level (2021-2030)	Average annual reduction rate of WLTP CO_2 target level (2021-2030)
TLC10	10%	1.2%
TLC20	20%	2.4%
TLC25	25%	3.2%
TLC30	30%	3.9%
TLC40	40%	5.5%
TLC_EP40	40%	5.5% (8.0% for 2021-2025 and 3.5% for 2025-2030)
TLC_EP50	50%	7.4%

Option TLC_EP40 differs from option TLC40 by defining a non-linear target trajectory. This covers the strictest end of the 2025 target range referred to in the Statement by the

[62] Commission Delegated Regulation (EU) 2017/1502 of 2 June 2017 amending Annexes I and II to Regulation (EC) No 443/2009, OJ L 221, 26.8.2017, p. 4 and Commission Delegated Regulation (EU) 2017/1499 of 2 June 2017 amending Annexes I and II to Regulation (EU) No 510/2011, OJ L 219, 25.8.2017, p. 1

Commission in 2014 in the context of the negotiations on the Cars Regulation[63]. This also holds true for option TLC_EP50, which defines a 2030 target that is 50% lower than the 2021 target.

Figure 5: EU-wide fleet target level trajectories for new cars under the different TLC options[64]



5.1.1.2 CO_2 target level for vans (TLV)

- Option TLV 0: Change nothing (baseline)

  This option represents the status quo, meaning that the CO_2 target level set in the current Regulation is maintained after 2021 (WLTP equivalent of 147 g CO_2/km NEDC as EU-wide fleet average).

- The other options for defining the EU-wide fleet CO_2 target level for light commercial vehicles are summarised in the below table.

Option	Decrease of WLTP CO_2 target level (2021-2030)	Average annual reduction rate of WLTP CO_2 target level (2021-2030)
TLV10	10%	1.2%
TLV20	20%	2.4%
TLV25	25%	3.1%
TLV30	30%	3.9%

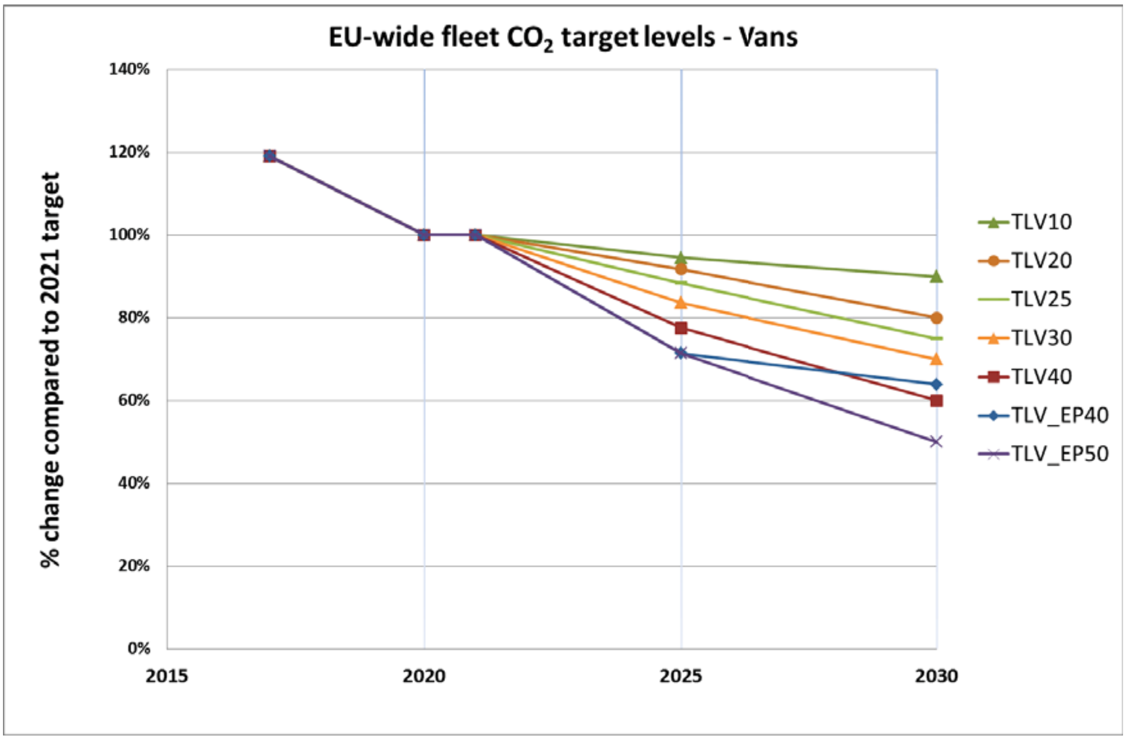
[63] "In carrying out its impact assessment of a 2025 target the Commission will consider the appropriateness of a range of ambition levels/rates of reduction, coherent with the long term climate goals of the EU and the emission reduction trajectory referred to in recital 7 of Regulation (EU) No. xxx/2013. This assessment will cover the range of ambition sought by the European Parliament for a 2025 target in the range of 68g to 78g CO_2/km, equivalent to 4-6% reduction per year in relation to the 2020 target." (http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%206642%202014%20ADD%201%20REV%201)

[64] The figure shows the evolution over time, relative to the target of 95 g CO_2/km NEDC, which applies in 2021 (100%). The future targets will be set in g CO_2/km WLTP.

TLV40	40%	5.5%
TLV_EP40	36%	4.4% (8.1% for 2021-2025 and 2.2% for 2025-2030)
TLV_EP50	50%	7.4% (8.1% for 2021-2025 and 6.9% for 2025-2030)

Options TLV_EP40 and TLV_EP50 are defining a non-linear target trajectory, covering the strictest end of the 2025 target range referred to in the Statement by the Commission in 2014 in the context of the negotiations on the Vans Regulation[65]. For 2025, both options cover a WLTP target equivalent to 105 g CO_2/km NEDC, while in 2030 the targets are 36%, respectively 50%, lower than the 2021 targets.

Figure 6: EU-wide fleet target level trajectories for new vans under the different TLV options[66]



5.1.2 Timing of the CO_2 targets (TT)

The following options will be considered for defining the year(s) for which new targets are set. These options apply both for passenger cars (in relation to options TLC) and for light commercial vehicles (in relation to options TLV).

[65] "In carrying out its impact assessment of a 2025 target, the Commission will consider the appropriateness of a range of ambition levels/rates of reduction, coherent with the long term climate goals of the EU and the necessary emission reduction trajectory. This assessment will cover the range of ambition sought by the European Parliament for a 2025 target in the range of 105 g to 120 g CO_2/km, equivalent to 3-4 % reduction per year in relation to the average 2012 emissions from new light commercial vehicles." (http://register.consilium.europa.eu/doc/srv?l=EN&f=ST%205584%202014%20ADD%201) The average 2012 emissions from new light commercial vehicles were 180 g CO_2/km.

[66] The figure shows the evolution over time, relative to the target of 147 gCO_2/km NEDC which applies in 2020-2021 (100%). The future targets will be set in g CO_2/km WLTP.

- Option TT 1: The new EU-wide fleet CO_2 targets start to apply in 2030.

  This means that the (WLTP equivalent of the) CO_2 target levels set in the Cars and Vans Regulations would continue to apply until the year 2029.

- Option TT 2: New EU-wide fleet CO_2 targets start to apply in 2025 and will continue to apply until 2029, and stricter EU-wide fleet CO_2 targets start to apply from 2030 on.

  Under this option, the new EU-wide fleet targets for 2025 and 2030 are calculated according to the annual average reduction rates set out in Section 5.1.1.

- Option TT 3: New EU-wide fleet CO_2 targets are defined for each of the years 2022-2030.

  Under this option, new annual EU-wide fleet CO_2 targets are calculated according to the annual average reduction rates set out in Section 5.1.1

These options include a mid-term review to assess the effectiveness of the policy.

5.1.3 Metric for expressing the targets

The CO_2 targets set in the Cars and Vans Regulations relate to the tailpipe emissions of newly registered vehicles, applying the so-called Tank-to-Wheel approach (TTW). The targets are expressed in g CO_2 /km and apply for the sales-weighted average emissions of the EU-wide fleet. For calculating the average, each newly registered vehicle is counted equally.

Using a TTW metric allows focusing on vehicle efficiency, which has proven to be an effective way of triggering the uptake of vehicle technology and starting a shift towards alternative powertrains. However, the overall GHG emission impact of using (new) vehicles is also affected by the type of fuel/energy used to propel the vehicle, as different energy types differ in the amount of CO_2 emissions generated during their production, the so-called Well-To-Tank (WTT) emissions. The sum of the TTW emissions and the WTT emissions is referred to as the Well-To-Wheels (WTW) emissions.

Furthermore, there are also CO_2 emissions associated with vehicle manufacturing (including the mining, processing and manufacturing of materials and components), maintenance and disposal. These are referred to as "embedded" CO_2 emissions. For determining those emissions, information is needed concerning the different phases of a vehicle's life cycle and tools such as life-cycle assessment (LCA) are often used for this purpose.

The g CO_2/km metric allows comparing the emission performance of vehicles on a unit distance basis, but this does not reflect the total emissions of a vehicle over its lifetime. Vehicles with a higher lifetime mileage may contribute more to total CO_2 emissions compared to vehicles that are used less intensively, even where the latter perform worse against the g CO_2/km targets.

The evaluation study noted that the effectiveness of the Cars and Vans Regulations might have been reduced because some of the emission reductions achieved in terms of tailpipe CO_2 emissions may have been accompanied by increased emissions elsewhere.

During the public consultation, some stakeholders also suggested to switch to other metric types to express the targets, in particular by using one of the approaches mentioned hereafter.

Well-to-Wheel (WTW) based metric

In the public consultation, stakeholders representing the fuels industry as well as some component suppliers suggested a change from the TTW metric to a WTW based metric, which takes into consideration the sum of the TTW and WTT emissions in the CO_2 target levels. By contrast, consumer organisations, car manufacturers and stakeholders from the power sector did not support such a change. Public authorities had mixed views.

Metric taking into account embedded emissions

In the public consultation, most car manufacturers were against changing to this approach, whereas other stakeholder groups had diverging views.

Metric based on mileage weighting

During the public consultation, the question whether average mileage by fuel and vehicle segment should be taken into account when establishing targets received very mixed replies from stakeholders. A number of environmental and transport NGOs, some research institutions, and all respondents from the petroleum sector were in favour of doing so. By contrast, one NGO and the majority of car manufacturers were against this option. Most consumer organisations were neutral on the issue, whereas public authorities expressed split views.

In the light of the above and the views expressed during the public consultation, the following options will be considered for defining the metric of the EU-wide fleet CO_2 targets. These options apply both for passenger cars and for light commercial vehicles.

- Option TM_TTW: change nothing, TTW approach

  This option maintains the current metric for setting the targets, i.e. targets expressed in g CO_2/km based on a TTW approach and applying for the sales-weighted average EU-wide fleet emissions.

- Option TM_WTW: WTW approach

  Under this option, the target would be expressed in g CO_2/km based on a WTW approach and would apply for the sales-weighted average EU-wide fleet emissions.

- Option TM_EMB: metric covering embedded emissions

  Under this option, the target would be expressed in g CO_2/km covering both WTW and embedded emissions and it would apply for the sales-weighted average EU-wide fleet emissions.

- Option TM_MIL: metric based on mileage weighting

  Under this option, the target would be set in relation to the mileage-weighted average EU-wide fleet emissions. It could either be expressed in g CO_2/km or in different units reflecting the difference in lifetime mileage between vehicle groups.

5.2 Distribution of effort (DOE)

The Cars and Vans Regulations use a limit value line to define the specific emission targets for individual manufacturers, starting from the EU-wide fleet targets. This linear curve defines the relation between the CO_2 emissions and a "utility parameter" (currently: vehicle mass in running order[67]).

[67] This is defined as "mass of the vehicle, with its fuel tank(s) filled to at least 90 % of its or their capacity/ies, including the mass of the driver, of the fuel and liquids, fitted with the standard

On this line, the EU-wide fleet target value corresponds with the average mass of the new vehicles in the fleet (M0). The slope of the line is the key factor in distributing the EU-wide fleet target as it determines to what extent vehicles (manufacturers) with a higher/lower (average) mass will be allowed/required to have higher/lower CO_2 emissions than the EU-wide fleet average. The steeper the slope, the larger the difference in specific emission targets between manufacturers with "heavy" and "light" vehicles.

In order to avoid that the EU-wide fleet targets would be altered due to an autonomous change in the average mass of the fleet, the M0 values are readjusted every three years to align them with the average mass of the new fleet of the previous years.

The choice of slope of the limit value line is merely a decision on how to share efforts amongst manufacturers and does not affect the overall emission target for the EU fleet of new vehicles.

Other approaches (e.g. using another or no utility parameter, changing the slope of the line, using a non-linear curve) are possible for distributing the effort required from each manufacturer in meeting the EU-wide fleet target. The Cars and Vans Regulations explicitly request the Commission to review this modality[68].

Most car manufacturers and consumer organisations responding to the online consultation were in favour of using a utility parameter to distribute the effort between different manufacturers. A relatively large number of stakeholders across different stakeholder groups were neutral on this question, and only a small number of stakeholders (from different groups) were against the use of a utility parameter. Views diverged on which utility parameter to use. All consumer organisations, some environmental and transport NGOs as well as stakeholders from the petroleum sector supported footprint[69], while most car manufacturers supported mass as utility parameter. Only two stakeholders referred explicitly to another parameter (loading capacity, in the case of light commercial vehicles).

The Association of European automobile manufacturers suggested a slightly different approach for cars and vans. While maintaining a single linear curve for cars with a mass-based utility parameter (*i.c.* WLTP test mass[70]), for vans they proposed to switch to a curve consisting of two linear parts with different slopes, arguing that this would better take account of the large variety in design of light commercial vehicles.

---

equipment in accordance with the manufacturer's specifications and, when they are fitted, the mass of the bodywork, the cabin, the coupling and the spare wheel(s) as well as the tools" (Article 2(4)) of Commission Regulation (EU) No 1230/2012 of 12 December 2012 implementing Regulation (EC) No 661/2009 of the European Parliament and of the Council with regard to type-approval requirements for masses and dimensions of motor vehicles and their trailers and amending Directive 2007/46/EC of the European Parliament and of the Council)

[68] In particular, the Commission is requested to review whether "a utility parameter is still needed and whether mass or footprint is the more sustainable utility parameter, in order to establish the CO_2 emissions targets for new passenger cars for the period beyond 2020."

[69] In this context, the "footprint" of a vehicle is defined as the product of its wheelbase and track width, measured in m².

[70] The WLTP test mass includes the mass in running order as well as the mass of optional equipment fitted to individual vehicles and the vehicle. By contrast, NEDC tests are based on the reference mass. The WLTP test mass is expected to better reflect the actual mass of the vehicles put on the road. While the test mass is not yet monitored or reported, this will be the case once the WLTP is being implemented (from 2018 onwards). See also TNO (2016): NEDC – WLTP comparative testing, TNO 2016 R11285, http://publications.tno.nl/publication/34622355/ZCzWY2/TNO-2016-R11285.pdf

In view of this, the following options are being considered:

- Option DOE 0: Change nothing

Under this option the linear limit value curves as defined in the current Regulations are maintained. The utility parameter applied is the mass in running order and the slope of the curves is 0.0333 (cars) and 0.096 (vans). The adjustment of the M0 value takes place every three years.

- Option DOE 1: mass based limit value curve with a slope representing an equal reduction effort for all manufacturers

Under this option, the manufacturer specific emission targets would be derived from the EU-wide fleet target according to a limit value line with the mass of the vehicles as the utility parameter.

The slope of the limit value line would be determined so that it results in an equal reduction effort for all manufacturers – starting from 2021 - according to the given utility value[71]. Two variants will also be considered as part of the assessment, one using the WLTP test mass as utility parameter (instead of mass in running order) and one using a combination of two different slopes for vans (taking account of the vehicle characteristics within the lighter and heavier segments).

- Option DOE 2: footprint based limit value curve with a slope representing an equal reduction effort for all manufacturers

Under this option, the specific emission targets would be derived from the EU-wide fleet target according to a limit value line using the vehicle footprint (i.e. wheelbase multiplied by track width) as the utility parameter. The approach for defining the slope would be the same as under option DOE 1, but using footprint data instead of mass data.

For options DOE 1 and DOE 2, other sub-options (with different slopes) had initially been considered, but were not withheld as they would either lead to unwanted effects (in case of higher slopes) or are very close to the other options explored (esp. DOE 4 in case of lower slope).

- Option DOE 3: same target for all manufacturers ("uniform target")

Under this option, the EU-wide fleet target would apply for each individual manufacturer and no utility parameter would be applied[72]. As the specific emission targets under the current Regulations vary according to the average mass of the new vehicles registered by a manufacturer, the (percentage) emission reductions required to meet the future targets would be larger for manufacturers having a higher average vehicle mass than for those having lighter vehicles.

- Option DOE 4: equal reduction percentage for all manufacturers

[71] The limit value line is constructed by firstly plotting the (WLTP equivalent of the) CO_2 emission values for the reference year for all vehicles registered in that year as a function of their mass. The slope of the line representing the sales-weighted least squares fit of the plotted points is the "reference slope". For a given target year, the ratio between the average EU-wide fleet emissions in the reference year and the EU-wide fleet target level in that year is determined. Multiplying the reference slope by that ratio gives the slope of the new limit value curve for the given year and target level. This line reflects an equal reduction effort for all manufacturers according to the given utility value.

[72] Another way of looking at this is that the slope of the limit value function becomes zero (flat limit value curve).

As in option DOE 3, no utility parameter would apply in this case. The same emission reduction percentage would be required for each manufacturer, taking its specific emissions target in 2021 as the starting point. Therefore, the future specific emission targets (in g/km) would differ amongst manufacturers, depending on their 2021 WLTP target[73].

Under options DOE 3 and DOE 4, the future manufacturer specific emissions targets would not be affected by future changes in the average value of the utility parameter for that manufacturer's new vehicles (mass or footprint).

5.3 ZEV/ LEV incentives

5.3.1 Context

The transition to low- and zero-emission mobility is subject to a number of policy discussions. At the informal meeting of the Environment and Transport Ministers in Amsterdam in April 2016, Member States supported this transition and underlined the opportunities it creates[74].

The May 2017 Communication, 'Europe on the Move: An agenda for a socially fair transition towards clean, competitive and connected mobility for all'[75] confirms that EU-wide carbon dioxide emissions standards are a strong driver for innovation and efficiency and will contribute to strengthening competitiveness and pave the way for zero and low-emission vehicles in a technology-neutral way. It also stated that options under review include specific targets for low and/or zero-emission vehicles.

The Communication builds on the earlier Commission's European Strategy for Low-Emission mobility[76], published in July 2016, in which the Commission highlighted the important role of zero- and low-emission vehicles in delivering CO_2 reductions, particularly in view of the longer-term decarbonisation objectives. Furthermore, the Commission stressed that accelerating the ongoing shift to low-emission mobility will offer major opportunities for the European automotive and other sectors to drive global standards and export their products. Fostering a domestic lead market for such vehicles is relevant from a competitive perspective, in order to create (1) economies of scale to drive down costs and (2) a competitive edge for European manufacturers and component suppliers.

The battery is a major cost component of a BEV with battery costs making up to 55% in the price of a mass manufactured BEV in 2016[77]. According to external studies, a broad range of EV support policies applied worldwide[78] is expected to contribute to a drastic

[73] Those WLTP targets will be derived from the NEDC targets, which will differ between manufacturers according to the limit value curves defined in the current Regulations (Commission Delegated Regulations (EU) 2017/1502 and (EU) 2017/1499).

[74] Informal meeting of the Environment and Transport Ministers, 14-15 April 2016 – Information note of the Presidency (http://data.consilium.europa.eu/doc/document/ST-10203-2016-INIT/en/pdf)

[75] COM(2017) 283 final

[76] https://ec.europa.eu/transparency/regdoc/rep/1/2016/EN/1-2016-501-EN-F1-1.PDF

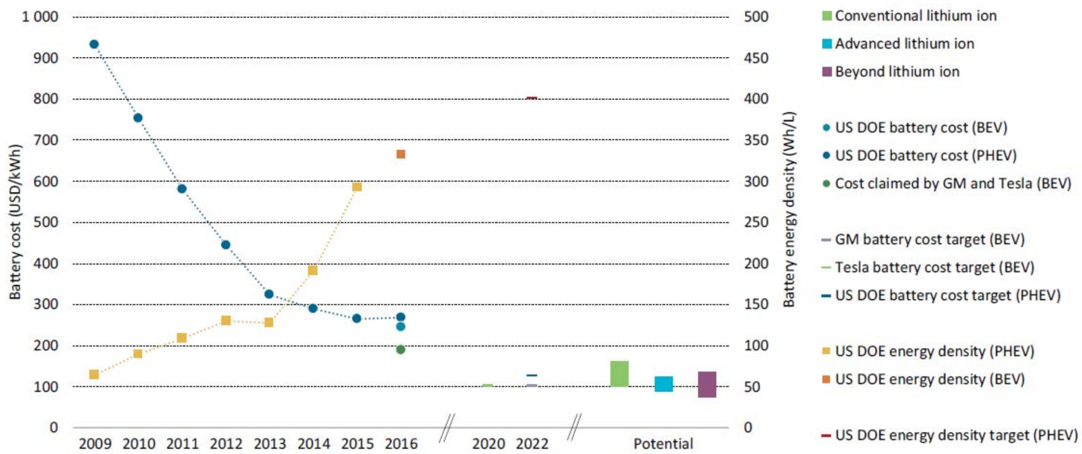
[77] N. Soulopoulos, (2017) When Will Electric Vehicles be Cheaper than Conventional Vehicles? (Bloomberg New Energy Finance) - https://data.bloomberglp.com/bnef/sites/14/2017/06/BNEF_2017_04_12_EV-Price-Parity-Report.pdf

[78] OECD/IEA (2017) Global EV Outlook 2017 (https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf)

reduction in cost of electric vehicles over the next decade as battery manufacturing gets cheaper[79]. Those cost reductions are however highly reliant on mass manufacturing. Analysts argue that policy is therefore critical in this respect and fuel economy regulations will play an important role in driving the scale-up in EV manufacturing over the next 5-7 years[80].

Figure 7 summarises information available up to 2016 on the costs and volumetric energy densities of batteries currently being researched, as well as the ranges of cost reductions that can be expected from the three main families of battery technologies: conventional lithium ion; advanced lithium ion, using an intermetallic anode (i.e. silicon alloy-composite); and technologies going beyond lithium ion (lithium metal, including lithium sulphur and lithium air)[81]. Figure 8 illustrates the evolution of Li-ion battery costs (in USD/kWh) in the past decade (showing a decrease of around 70% since 2010) and a forecast of their further evolution towards 2030, based on expected demand[82, 83].

Figure 7: Battery costs (USD/kWh) and battery energy density (Wh/L)



Source: OECD/IEA (2017) Global EV Outlook 2017

79 ICCT project that 2015 and 2030 PHEVs will achieve about a 50% cost reduction, BEVs 60% and FCEVs 70% ('Electric Vehicles: Literature review of technology costs and carbon emissions', 2016, http://www.theicct.org/lit-review-ev-tech-costs-co2-emissions-2016).
Bloomberg estimates that battery costs are reducing by 19% per cumulative doubling of manufactured capacity, which means that battery cell prices could more than halve between 2015 and 2025. (When Will Electric Vehicles be Cheaper than Conventional Vehicles? (N. Soulopoulos, Bloomberg New Energy Finance, 2017) https://data.bloomberglp.com/bnef/sites/14/2017/06/BNEF_2017_04_12_EV-Price-Parity-Report.pdf

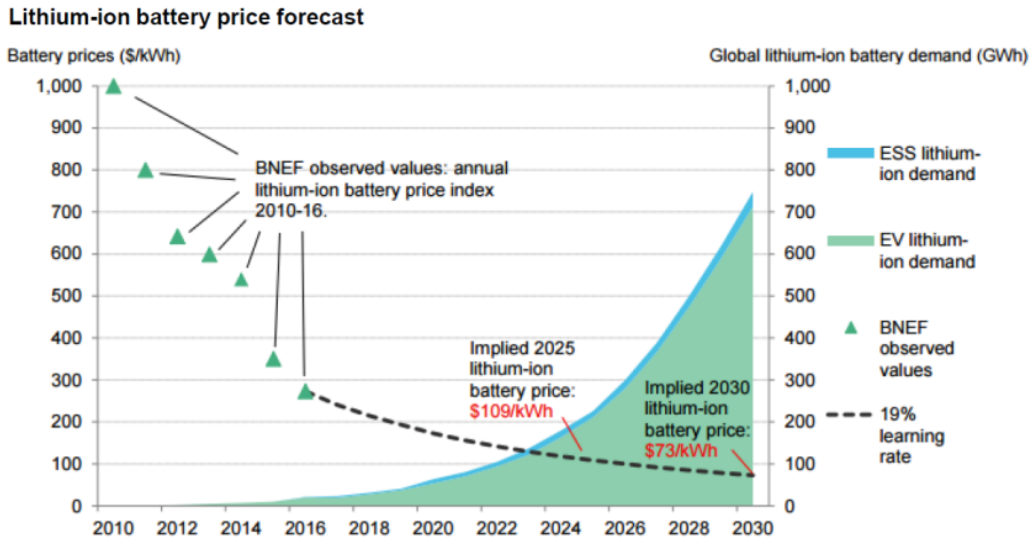
80 N. Soulopoulos, (2017) When Will Electric Vehicles be Cheaper than Conventional Vehicles? (Bloomberg New Energy Finance)

81 OECD/IEA (2017) Global EV Outlook 2017

82 Bloomberg New Energy Finance (2017) (presentation by Michael Liebreich at the Bloomberg New Energy Finance Global Summit, New York, April 2017) (https://about.bnef.com/blog/liebreich-state-industry-keynote-bnef-global-summit-2017/)

83 Bloomberg New Energy Finance (2017): "Global Trends in Clean Energy and Electric Mobility" (presentation by Michael Liebreich, Berlin, 10 May 2017) (https://www.agora-energiewende.de/fileadmin/Projekte/2017/VAs_sonstige/Clean_Energy_Electric_Mobility/Liebreich_Global_Trends_Event_10052017.pdf)

Figure 8: Evolution of Li-ion battery costs (USD/kWh)



Source: Bloomberg New Energy Finance (2017)

In addition, the narrowing cost gap between electric cars and ICEV may put pressure on governments to gradually revise their support measures, phasing out incentives in cases where BEVs and PHEVs actually rival ICEV costs. According to a report by OECD/IEA, other regulatory instruments (such as including fuel economy regulations and local measures, such as differentiated access to urban areas) will remain important in supporting the electric car uptake needed to meet the targets characterising a low-emission future[84].

Regulatory incentives might thus be needed to help overcome the barriers to the market uptake of ZEVs and LEVs.

The vehicles incentivised should have a significant potential contribution to reducing the CO_2 emissions of the new car and van fleet. The types of vehicle most relevant in this respect are the following:

- Battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV), both having zero tailpipe CO_2 emissions and a limited market uptake so far.
- Plug-in hybrid electric vehicles (PHEV) with sufficiently low tailpipe CO_2 emissions.

In their replies to the public consultation, a majority of stakeholders across all stakeholder groups was in favour of some mechanism to encourage the deployment of LEV/ZEV, except for consumer organisations which were mostly neutral on whether and how LEVs/ZEVs should be incentivised. Environmental and transport NGOs were mostly in favour of a flexible mandate, differentiating between LEV and ZEV and allowing trading among manufacturers. European car manufacturers argued for considering broader policy issues such as grid management, infrastructure and taxation policy.

[84] Global EV Outlook 2017 (OECD/IEA, 2017) (https://www.iea.org/publications/freepublications/publication/global-ev-outlook-2017.html

The European Automobile Manufacturers Association (ACEA) is opposed to sales mandates for LEV/ZEV as it considers the market uptake to be mainly driven by public incentives, in particular fiscal measures, which would give car manufacturers limited control to meet such mandates.[85] They also refer to experience in markets with existing mandates where customers are not willing to buy LEV/ZEV. Car manufacturers also point to the need to increase the number of publically available charging points which does not fall under their responsibility.

At the same time, over the past few years, several major car manufacturers have been announcing their global ambitions for the sales of electric cars, which would result in a strongly increasing deployment of those vehicles in the following years. Table 4 summarises a number of those announcements.

Table 4: List of manufacturer's announcements on electric car ambition (adapted from 'Global EV outlook 2017' (OECD/IEA, 2017)[86])

Manfacturer	Announcement
BMW	0.1 million electric car sales in 2017 and 15-25% of the BMW group's sales by 2025[87]
Chevrolet (GM)	30 thousand annual electric car sales by 2017
Chinese manufacturers*	4.52 million annual electric car sales by 2020 equivalent to around 20% of total expected production and sales in China.
Daimler	0.1 million annual electric car sales by 2020; 15-25% of total sales (Mercedes and Smart) with electric powertrain by 2025[88]
Ford	13 new EV models by 2020
Honda	66% of the 2030 sales to be electrified vehicles (including hybrids, PHEVs, BEVs and FCEVs)
Renault-Nissan	1.5 million cumulative sales of electric cars by 2020; aspirational target of more than 20% of total sales to be equpped with electric powertrain by 2022[89]
Tesla	0.5 million annual electric car sales by 2018 1 million annual electric car sales by 2020
Volkswagen	2-3 million annual electric car sales by 2025; 20-25% of VW Group's global sales to be "battery electric vehicles" by 2025[90]
Volvo	1 million cumulative electric car sales by 2025 all new models will have an electric motor, including fully electric

[85] ACEA (2017) Decarbonisation of transport – impact on jobs, stakeholder meeting, Brussels, 26 June 2017

[86] OECD/IEA (2017), 'Global EV outlook 2017' (Table 2)

[87] https://www.press.bmwgroup.com/global/article/detail/T0273122EN/bmw-group-announces-next-step-in-electrification-strategy?language=en

[88] http://www.manager-magazin.de/unternehmen/autoindustrie/daimler-mehr-als-eine-milliarde-euro-pro-jahr-fuer-elektroautos-a-1117695.html

[89] http://www.france24.com/en/20170915-renault-nissan-launch-12-zero-emission-models

[90] https://www.volkswagen-media-services.com/en/detailpage/-/detail/New-Group-strategy-adopted-Volkswagen-Group-to-become-a-world-leading-provider-of-sustainable-mobility/view/3681833/7a5bbec13158edd433c6630f5ac445da

	cars, plug-in hybrids and mild hybrids from 2019[91]

*Note: Chinese manufacturers include BYD, BJEV-BAIC Changzhou factory, BJEV-BAIC Qingdao factory, JAC Motors, SAIC Motor, Great Wall Motor, GEELY Auto Yiwu factory, GEELY Auto Hangzhou factory, GEELY Auto Nanchong factory, Chery New Energy, Changan Automobile, GAC Group, Jiangling Motors, Lifan Auto, MIN AN Auto, Wanxiang Group, YUDO Auto, Chongqing Sokon Industrial Group, ZTE, National Electric Vehicle, LeSEE, NextEV, Chehejia, SINGULATO Motors, Ai Chi Yi Wei and WM Motor.

Despite this willingness by manufacturers to strongly expand their offer of EVs, the IEA[92] argues that at this stage of the electric car market deployment, policy support remains "indispensable for lowering barriers to adoption". In this context the IEA notes that mandates in combination with targets provide a clear signal to manufacturers and customers.

As a follow-up to the EMIS Inquiry Committee, the European Parliament[93] in April 2017 called on the Commission to fully engage in and implement a low-emission mobility strategy and "to come forward with a draft regulation on CO_2 standards for the car fleets coming onto the market from 2025 onwards, with the inclusion of Zero-Emission Vehicles (ZEV) and Ultra-Low Emission Vehicles (ULEV) mandates that impose a stepwise increasing share of zero- and ultra-low-emission vehicles in the total fleet with the aim of phasing out new CO_2-emitting cars by 2035".

A regulatory instrument to enhance the uptake of LEV has been established since the early 1990s in California with the "ZEV Regulation", which requires manufacturers to market a certain percent of vehicles with (near-)zero tailpipe emissions (see Box 2)[94]. Similar mandates also apply in nine other States of the US[95]. In September 2017, China adopted new energy vehicle (NEV) mandates (see Box 3) for the sales of electric cars, which, combined with government and local incentives for customers, manufacturers and the development of infrastructure, have seen a very strong growth in the past few years. Most recently, Quebec has adopted a ZEV mandate[96]. In the light of this policy context, the Impact Assessment is considering several options described below.

Box 2: California's ZEV programme[97]

California introduced a ZEV mandate already in 1990. It required manufacturers to progressively increase the sales volume of BEVs to 2% of new vehicle sales by 1998 and 10% by 2003. Given the early stage of development of electric vehicles at the time, the initial ZEV mandate turned out

[91] Volvo Car Group (2017): Volvo Cars to go all electric, (https://www.media.volvocars.com/global/en-gb/media/pressreleases/210058/volvo-cars-to-go-all-electric)

[92] OECD/IEA (2017), 'Global EV outlook 2017'

[93] European Parliament Recommendation of 4 April 2017 to the Council and the Commission following the inquiry into emission measurements in the automotive sector (http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//NONSGML+TA+P8-TA-2017-0100+0+DOC+PDF+V0//EN)

[94] https://www.arb.ca.gov/msprog/zevprog/zevprog.htm

[95] Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island and Vermont.

[96] The mandated new ZEV market shares, which are modelled after California's approach, are 3.4% in 2018, 6.9% in 2020 and 15.5% in 2025.

[97] https://www.arb.ca.gov/msprog/zevprog/zevprog.htm

to be too ambitious and was subject to a number of modifications since then.[98] The current ZEV Regulation requires vehicle manufacturers with an annual production of more than 4,500 vehicles to bring to and operate in California a certain percent of "ZEVs" (i.e. BEV, FCEV and PHEV; up to 2017, ZEV credits may also be obtained for "partial" ZEV (PZEV), such as clean hybrids and clean gasoline vehicles) . The ZEV Regulation has become incrementally more stringent and will continue to do so until 2025. From 2018 they include a minimum ZEV floor requirement for large manufacturers (i.e. annual production of more than 60,000 vehicles) above which manufacturers may use credits to meet their total ZEV requirement.

The Californian "ZEV" standards have in the meantime been adopted by nine other States in the U.S. (29% of all new cars sold in the U.S. are sold in these 10 States).[99] However, in 2016 the actual share of BEV, PHEV and FCEV in new car sales was only around 3% in California and less than 1% in the U.S. as a whole.[100] In its recent Midterm Review CARB notes that costs for batteries (as well as other component costs) have fallen "dramatically" (largely due to reduced material costs, manufacturing improvements, and higher manufacturing volumes). Moreover, the number of PHEV and BEV models offered on the market is expected to increase from 25 today to more than 70 models over the next 5 model years. Since 2012 car manufacturers had been over-complying with the ZEV standards and accumulated ZEV credits in view of meeting future ZEV requirements.

Box 3: China's NEV mandate

In 2010 China introduced its new energy vehicle (NEV) programme setting a target of 1 million electric vehicles (including both light- and heavy-duty vehicles) by 2015. With the support of public incentives, sales of electric vehicles grew significantly in China in recent years with cumulative sales reaching nearly 1 million in 2016[101]. On 28 September 2017, the Chinese Ministry of Industry and Information Technology (MIIT) published the final rule on passenger car fuel economy standards with an integrated mandate for NEVs which covers battery electric (BEV), plug-in hybrid (PHEV) and fuel cell vehicles (FCEV).[102]

The legislation sets mandatory NEV requirements as from 2019: 10% in 2019 and 12% in 2020; requirements for 2021 and beyond are yet to be determined by MIIT. The requirements are applicable to all manufacturers with annual production or import volume of 30,000 or more conventional-fuelled passenger cars. In order to meet the requirements, manufacturers can generate new energy vehicle scores by producing or importing NEVs. A company’s actual NEV score is calculated by summing up the products of annual manufacturing or import volume of each NEV and the per-vehicle NEV score. The per-vehicle score depends mainly on the electric range for BEV, whereas for PHEV and FCEV other factors are taken into account such as electric consumption. The highest score of 5 can be reached by BEV, whereas PHEV can reach a maximum score of 2. NEV requirements are therefore not equivalent to the market share of NEVs in China in 2019 and 2020. For instance, e.g. for meeting 10% NEV requirement in 2019

[98] Vergis, S. and Mehta, V. (2012): Technology innovation and policy: a case study of the California ZEV mandate, in: Nillsson, M., Hillman, K., Ricken, A., Magnusson, T.: Paving the road to sustainable transport: governance and innovation in low-carbon vehicles. Abingdon: Routledge

[99] CARB (2017): California’s Advanced Clean Cars Midterm Review - Summary Report for the Technical Analysis of the Light Duty Vehicle Standards, https://www.arb.ca.gov/msprog/acc/mtr/acc_mtr_summaryreport.pdf

[100] Reuters (2017): Zero-emission vehicle sales in the U.S., http://fingfx.thomsonreuters.com/gfx/rngs/california-electriccars/010021FJ3JD/index.html

[101] EIU (2017): China's new NEV rules, http://www.eiu.com/industry/article/1185390902/chinas-new-nev-rules/2017-05-03

[102] http://www.miit.gov.cn/n1146295/n1146557/n1146624/c5824932/content.html

with BEVs only, a manufacturer would need a BEV share of 2% only. A company generates NEV credits if its actual NEV score is higher than its NEV requirement. It will face a NEV score deficit if its actual NEV score is below the target. If a manufacturer cannot reach its NEV target in 2019, it can still meet its NEV requirement in 2020. A positive NEV quota can be traded between manufacturers but cannot be carried over to following year(s) after 2019, except from 2019 to 2020. Manufacturers are allowed to use NEV credits towards compliance with existing fuel economy standards.

5.3.2 Policy options

- Option LEV 0: Change nothing

  This option assumes that, apart from the fleet-wide CO_2 emission targets, the legislation will not include provisions, which would specifically aim to increase the number of ZEV or LEV registered. The assessment of this option will therefore be based on the assessment of the TLC and TLV options

For the other policy options for incentivising ZEV/LEV, three key elements are considered: (i) the definition of a low-emission vehicle, as this determines the scope of the incentive, and (ii) the type of incentive and (iii) the level of the LEV incentive.

In addition, elements related to the implementation of the incentive need to be considered, such as compliance assessment (incl. the link with the CO_2 target), differentiation between OEMs and between different types of LEV.

5.3.2.1 LEV definition (LEVD)

In order to identify which vehicles would qualify for the LEV incentive, it is necessary to define what constitutes a LEV. This requires consideration of the metric and threshold to be used.

An option initially considered was to use the zero emission range of a vehicle (in km) for defining a LEV. However, this approach was not considered further, as the link of this metric with CO_2 emissions is less outspoken, and only limited data is available to decide on an appropriate WLTP value. This view is also supported by the majority of stakeholders from different stakeholder groups which clearly preferred the use of CO_2 emission performance as the criterion for defining LEV, with proposed thresholds ranging from 15g CO_2/km to 50g CO_2/km.

Therefore, as regards the CO_2 emission threshold, only the options for defining a LEV according to its tailpipe CO_2 emissions will be further considered, as summarised in Table 5.

Table 5: Options considered for the LEV definition (LEVD)

Option	LEV definition
LEVD_ZEV	only vehicles with CO_2 emissions of zero qualify as a LEV (LEV = ZEV)
LEVD_25 (for cars) LEVD_40 (for vans)	LEV are all vehicles with CO_2 emissions of less than or equal to 25 g CO_2/km (for cars) or 40 g CO_2/km (for vans)
LEVD_50	LEV are all vehicles with CO_2 emissions of less than 50 g CO_2/km (with counting of LEV on the basis of their CO_2 emissions)

The higher threshold for vans under option LEVD_40 compared to cars (LEVD_25), is explained by their larger average mass compared to cars and by the uncertainty over the feasibility of bringing a sufficient number of PHEV vans with emissions below 25 g CO_2/km to the market.

For option LEVD_50, the 50 g CO_2/km threshold is the same one as set in Article 5 of the Cars and Vans Regulations for vehicles to be eligible for generating super-credits. With the change from NEDC to WLTP, type approval emissions from PHEV with emissions around 50 g CO_2/km are not expected to change significantly (see Annex 4.6).

However, covering such a broad range of vehicles without any further distinction would not take account of the expected improvement in battery efficiency and the corresponding decrease of CO_2 emissions from PHEV. Furthermore, the actual performance of PHEV on the road is strongly influenced by the type and duration of trips undertaken, external conditions (temperature) and consumer behaviour (charging, use of electric equipment).

Therefore, a distinction is proposed under this option between ZEV and other LEV, by counting each LEV in relation to its CO_2 emissions. While each ZEV would thus count as one vehicle, all other LEV would count as less than one vehicle, according to the following formula: $1 - \frac{\text{CO2 emissions of the LEV}}{50}$.

In this way, the incentive is targeted towards vehicles having near-zero emissions, which avoids over-incentivising PHEVs with a short electric range.

5.3.2.2 Type and level of incentive (LEVT)

Additional regulatory tools for incentivising the uptake of ZEV/LEV currently used are mostly based on a ZEV/LEV sales mandate (e.g. California) and/or a crediting system, through increasing the weighting of a ZEV/LEV in the calculation of average emissions or providing emission credits based on the sales share of qualified vehicles.

Under the current Cars and Vans Regulations, a "super-credit" modality has been established to incentivise manufacturers to produce vehicles emitting less than 50 g CO_2/km. During a limited number of years, such vehicles may be counted as more than one vehicle for the purpose of calculating the average specific emissions of a manufacturer.

For cars, super-credits applied between 2012 and 2015 in relation to the 130 g CO_2/km target and will again apply (with lower multipliers) between 2020 and 2022 in relation to the 95 g CO_2/km target (with a cap of 7.5 g CO_2/km per manufacturer over the three years). For vans, super-credits only apply between 2014 and 2017 in relation to the 175 g/km target (for a maximum of 25,000 vans over that period).

However, as already highlighted in the impact assessment underlying the 2012 proposals for amending the Cars and Vans Regulations[103], a super-credit system has significant drawbacks as it reduces the stringency of the CO_2 target and thus the effectiveness of the Regulations in reducing CO_2 emissions. The increase of CO_2 emissions depends *inter alia* on the multiplier used and the number of eligible vehicles. For example, with a multiplier of 3.5 (which was applicable in the Cars Regulation in 2012-2013 and in the Vans Regulation in 2014-2015), CO_2 emissions could increase by 3% to 15% depending on the proportion of vehicles qualifying for super-credits.

[103] SWD (2012)213final

The evaluation study confirmed that super-credits could potentially weaken the targets, but noted that this had not yet materialised (in 2015) in view of the very low uptake of vehicles emitting less than 50 g CO_2/km and as all major manufacturers were meeting their targets at that time even without taking super-credits into account.

However, as the share of vehicles with low emissions is expected to increase over time, maintaining the super-credit modality, as included in the Cars and Vans Regulations, would bear a high risk of weakening the CO_2 target.

This analysis is confirmed in recent studies[104,105] which highlight the substantial environmental cost of electric vehicle multipliers or super-credits, in particular as the share of low-emission vehicles in the fleet starts to increase. Super-credits are seen as a counterproductive long-term vehicle policy. As an example, it is calculated that with an electric vehicle penetration at 28% of new vehicle sales in Europe, the regulation would lose 41% of its intended CO_2 benefits when allowing super credits. Furthermore, as CO_2 targets get stricter, super-credits could even discourage the further deployment of LEVs after 2020 due to the multiple counting. Maintaining even a small multiplier of 1.33 (the lowest value used in the current Cars Regulation) could cause the market uptake of LEV to be reduced by 6-7% by 2030.

Finally, by applying a multiplier from the first LEV registered on, the current super-credits system fails to send a clear signal to manufacturers and authorities about the expected share of LEV in the fleet.

The main drawbacks of the super-credit system could be mitigated or overcome by redesigning it into a crediting system, which would incentivise the uptake of LEV beyond a given level and would avoid undermining the CO_2 target levels.

In view of the above, the following three options are considered:

- Option LEVT_MAND: LEV mandate

  Under this option, each manufacturer's new vehicle fleet would have to include at least a given share of LEV.

- Option LEVT_CRED1: LEV crediting system with one-way adjustment of the CO_2 target

  This option builds on and improves the current super-credits system. The LEV incentive would take the form of a crediting system in connection with a manufacturer's specific CO_2 target. A benchmark would be defined for the share of LEV in the new fleet in a given year. The specific CO_2 target of a manufacturer exceeding this LEV benchmark would be adjusted as follows: each LEV registration above the benchmark would be rewarded on a 1%/1% ratio, meaning that a manufacturer registering 1% more LEV than the benchmark would get a 1% less stringent CO_2 target. The CO_2 target adjustment would be limited to 5% in order to avoid it to be weakened too much. Assessing

[104] Element Energy (2016) Towards a European Market for Electro-Mobility (report for Transport & Environment) - https://www.transportenvironment.org/sites/te/files/Towards%20a%20European%20Market%20for%20Electro-Mobility%20report%20by%20Element%20Energy.pdf

[105] N. Lutsey (2017) Integrating electric vehicles within U.S. and European efficiency regulations (ICCT Working Paper 2017-07) (http://www.theicct.org/sites/default/files/publications/Integrating-EVs-US-EU_ICCT_Working-Paper_22062017_vF.pdf)

compliance would be done only against the CO_2 target. Not meeting the LEV benchmark would have no consequences for this compliance assessment.

- Option LEVT_CRED2: LEV crediting system with two-way adjustment of the CO_2 target

  This option only differs from option LEVT_CRED1 in that a manufacturer not meeting the LEV benchmark level would have to comply with a stricter specific CO_2 target. Again, each LEV registration below the benchmark would be counted at a 1%/1% ratio, meaning that a manufacturer registering 1% less LEV than the benchmark would get a 1% more stringent CO_2 target. The CO_2 target adjustment would also be limited to 5%. Not meeting the LEV benchmark would therefore be reflected in the compliance assessment through a more stringent CO_2 target.

As regards the percentage of the new vehicle fleet serving as the LEV mandate (LEVT_MAND) or benchmark (options LEVT_CRED), three options are considered for cars, labelled LEV%_A, LEV%_B and LEV%_C, and two options for vans, labelled LEV%_A and LEV%_B. The values chosen for the LEV mandate/benchmark are incremental compared to the LEV shares in the new vehicle fleet under option LEV0, while taking account of recent announcements by vehicle manufacturers as regards their expected LEV share. This is further explained in Section 0.

The assessment will be based on applying the same LEV mandate/benchmark for all manufacturers. The option of differentiating between OEMs has been not been withheld.

5.4 Elements for cost-effective implementation

5.4.1 Eco-innovations (ECO)

Article 12 of the Cars and Vans Regulations provides manufacturers with the possibility to take into account CO_2 reductions achieved by innovative technologies whose CO_2 reducing effect cannot be demonstrated through the official test procedure. Vehicle manufacturers and component suppliers may apply for the Commission's approval of a technology as an eco-innovation, if it fulfils the following basic conditions:

- The supplier or manufacturer must be accountable for the CO_2 savings achieved;
- The technologies must make a verified contribution to CO_2 reduction;
- The technologies must not be covered by the standard test cycle CO_2 measurement or by mandatory provisions covered by the so-called Union's integrated approach to reach 10 g CO_2/km (Article 1 and Article 12(2)(c) of the Cars Regulation[106], see below for more information).

Where an approved eco-innovation technology is fitted to a manufacturer's vehicles, the average specific emissions of that manufacturer may be reduced by the CO_2 savings from applying that technology, up to a maximum of 7 g CO_2/km per year.

The Commission is empowered to adopt detailed provisions on the application procedure, including on the implementation of the criteria listed above. So far, the Commission has adopted more than 20 decisions approving eco-innovations for use in cars, for instance LED lighting systems and more efficient alternators. No applications have yet been submitted with regard to vans.

[106] This criterion also applies in relation to vans.

Both the previous impact assessment[107] and the evaluation study concerning the Cars and Vans Regulations concluded that eco-innovations are effective and efficient as they help to reduce CO_2 emissions at a lower cost than alternative options. While it could be argued that the stringency of the targets as measured on the official test procedure would be reduced by this modality, this effect is balanced by the delivery of 'off cycle' emission reductions which cannot be measured on the test procedure and by setting a cap on the contribution of those reductions to the target achievement.

During the public consultation, a very large majority of stakeholders across all stakeholder groups was in favour of taking account of CO_2 emission reductions arising from eco-innovations. Moreover, the evaluation study concluded that there is evidence supporting that the introduction of the Regulations has had a positive impact on innovation through encouraging higher R&D, and the development and deployment of fuel efficient technologies in the market. A phase-out of the eco-innovation modality will therefore not be considered as an option.

The evaluation study as well as stakeholders have however raised the issue of the administrative burden linked to the application and certification of savings as an issue and have suggested that the eco-innovation regime could be simplified in order to ensure a wider up-take of eco-innovations in the EU fleet.

Under the Cars and Vans Regulations (Article 12), the Commission is empowered to adopt detailed provisions on the application process, through which it may address any issues related to the administrative burden for industry and/or authorities. The Implementing Regulations [108] set out the requirements for applications as well as for the certification by type approval authorities of the CO_2 savings from the approved technologies.

A revision of the Implementing Regulations is currently underway, with a view of adapting it to the new test procedure WLTP, but also to introduce a number of simplifications without changing the robustness of the assessment of the applications or the certification of the savings. The revision includes consideration of the US approach of determining off-cycle technologies with pre-defined CO_2 savings as well as the possibility for amending existing approval decision upon request by stakeholders or at the Commission's initiative.

In view of this, it can be concluded that the current concept of eco-innovations is both efficient in that approved innovations will reduce CO_2 emissions and cost-effective in that their cost should be lower than alternative options, while not causing any significant adverse effects with regard to the stringency of the targets.

Moreover, the current design of the provisions provides the Commission with the necessary powers to address effectively the concerns raised by stakeholders and identified in the relevant studies with regard to the administrative burden.

Against that background, it is considered that the current design of the eco-innovation modality is fit for purpose and can be maintained for the period 2022 to 2030. However, two issues require further consideration: the cap for the CO_2 savings and the current exclusion of mobile air-conditioning systems from being eligible as eco-innovations. Manufacturers have in the context of the introduction of the WLTP requested an increase in the 7 g CO_2/km cap. Manufacturers as well as component suppliers have also called

[107] SWD(2012) 213 final

[108] Implementing Regulations (EU) No 725/2011 and (EU) No 427/2014.

for including mobile air-conditioning systems in the eco-innovation regime, pending any further regulation of such systems under the type approval legislation.

Cap for the CO_2 savings

The current eco-innovation regime includes a cap of 7 g CO_2/km for the CO_2 savings that may be taken into account for compliance purposes. The cap applies regardless of the target level and vehicle category concerned. Until now, the up-take of eco-innovations has been limited (less than 1 g CO_2/km in average savings for the manufacturer with the highest number of eco-innovations). It is however expected that the amount of eco-innovation credits used by manufacturers will increase significantly towards the target years 2020-2021.

The 7 g CO_2/km cap has been set by reference to the emissions tested on the NEDC, while the EU-wide fleet CO_2 targets for the period 2022 to 2030 are to be based on the emissions measured on the new WLTP type approval test. By setting a cap on the eco-innovation savings, a balance is ensured between incentives given to efficiency improvements demonstrated on the official test procedure and those given for the development of more efficient and new technologies that are not covered by that test. That balance also takes into account the fact that the target level is set on the basis of the test procedure emissions only.

The majority of technologies that have already been approved as eco-innovations will continue to fall outside also the WLTP test and will thus still be eligible as eco-innovations. There is however still uncertainty with regard to the level of the savings that can be expected from those technologies within the new testing framework as well as for the potential for other off-cycle technologies.

Against that background, and in order to ensure a smooth transition from the NEDC to the WLTP testing conditions, it is proposed to maintain the cap at the level of 7 g CO_2/km pending the availability of more information with regard to the level of eco-innovation savings under the new WLTP test procedure.

In order to be able to take into account the experience that will be gained from the implementation of that procedure in the next couple of years, it is appropriate to consider an option providing the Commission with an empowerment to review the level of the cap so as to ensure that incentives given to eco-innovations remain balanced and effective over time.

Mobile air-conditioning systems (MAC systems)

Under the Cars and Vans Regulations, measures that are covered by the so-called "integrated approach" as defined in the 2007 Commission Communication on A Competitive Automotive Regulatory Framework for the 21st Century[109] are not eligible as eco-innovations[110]. This includes, inter alia, MAC systems.

All measures related to this "integrated approach", with the exception of MAC systems, are subject to mandatory measures. This concerns tyre pressure monitoring systems, tyre rolling resistance limits, gear shift indicators, fuel efficiency standards for vans and the use of biofuels. Mandatory measures addressing the efficiency of MAC systems have not

[109] COM(2007) 22 final. The measures listed under the "integrated approach" should represent an additional 10 g CO_2/km reduction with a view to bringing the EU fleet average emissions to a level of 120g CO_2 /km.

[110] Article 1 and Article 12(2)(c) of the Cars and Vans Regulations

yet been introduced and the WLTP test procedure, developed in the context of the UNECE, will not cover such systems in a foreseeable future.

Different studies[111] have pointed to the absence of measures addressing the efficiency of MAC systems as a draw-back, considering that MAC systems are one of the most important energy consumers on board vehicles, representing an average increase in fuel consumption in the order of 9%[112]. Furthermore, these systems are becoming standard equipment in new vehicles. The share of new cars equipped with MAC has risen from around 10% in 1993 to 85 % in 2011[113].

Against that background, it is appropriate to consider the option of incentivising more energy efficient MAC systems within the context of eco-innovations. More efficient MAC could reduce the overall fuel consumption by at least 1 or 2%[114].

It should also be noted that the US has introduced an off-cycle regime, according to which manufacturers that provide efficiency improvements in MAC systems can generate CO_2-efficiency credits. The credits generated by the use of efficient MAC systems represented an equivalent of around 1.9 g CO_2 /km in 2014 and in 2015.

It is therefore proposed to consider the option of extending the scope of the eco-innovation regime to include MAC systems.

In view of the above, the following options are considered:

- Option ECO 0: Change nothing
- Option ECO 1: Future review and possible adjustment of the cap on the eco-innovation savings

This option would maintain the current provisions of Article 12 of the Cars and Vans Regulations but would introduce an empowerment for the Commission to review and, where found appropriate following an assessment, adjust the 7 g CO_2/km cap set on the eco-innovation savings.

- Option ECO 2: Extend the scope of the eco-innovation regime to include MAC systems

This option would also maintain the provisions of Article 12 of the Cars and Vans Regulations including the empowerment to adjust the cap as described in ECO1 but would remove the exclusion of MAC systems from being eligible as eco-innovations. The design of the methodology for determining the efficiency of MAC systems would result from an application by a manufacturer or supplier which would have to be assessed and approved by the Commission.

[111] Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles; CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

[112] JRC (2016): Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/review-use-factors-affecting-fuel-consumption-and-co2-emissions-passenger-cars

[113] Hill, N., Walker, E., Beevor, J., James, K. (2011), '2011 Guidelines to Defra/DECC's GHG Conversion Factors for Company Reporting, Defra PB13625, UK.

[114] JRC (2016): Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/review-use-factors-affecting-fuel-consumption-and-co2-emissions-passenger-cars

5.4.2 *Pooling (POOL)*

The current Regulations (Article 7) offer individual manufacturers the possibility to form a "pool" for the purposes of meeting their emission targets. Such agreement enables a group of manufacturers to be counted as one entity for the purpose of compliance with the joint target. This allows manufacturers to decide on the most efficient way of complying with the targets. All manufacturers covered by the scope of the Regulations, which have not been granted a derogation (see section 5.4.5), could be part of a pool.

Pooling has been extensively used under the current Regulations. In 2015, pooling was used by 49 car manufacturers, responsible for 81% of all new car registrations in that year and by 25 van manufacturers, responsible for 70% of all new van registrations in that year. Forming a pool has prevented several manufacturers from exceeding their individual specific emissions target (in 2015 this was the case for 23 car manufacturers and 4 van manufacturers, which were member of a pool)[115].

The vast majority of pools have been formed by manufacturers belonging to the same group of connected undertakings. Independent manufacturers may also form pools, however, until now this possibility has been rarely used. A pool formed by independent manufacturers would, in accordance with competition rules, have to be open to the participation of any other manufacturer requesting to participate. This reduces somewhat the utility of such, so called "open", pools with regard to compliance planning.

In order to enhance pooling as an instrument for all manufacturers to reduce compliance costs, the conditions under which open pools may be formed by independent manufacturers and under which conditions another manufacturer may request to join an existing open pool could to be clarified. An option is therefore introduced whereby the Commission is empowered to complement the existing provision by developing specific criteria for the open pool arrangements, in particular with a view to address any relevant competition aspects.

In view of the above, the following options should be considered:

- Option POOL 0 – change nothing – current pooling regime
- Option POOL 1 – an empowerment for the Commission to specify the conditions for open pools arrangements

5.4.3 *Trading (TRADE)*

Trading has been suggested as a complement to pooling in order to provide additional flexibility for manufacturers in meeting the targets. Trading would allow individual manufacturers (or pools) to trade credits depending on their performance. This means that when a manufacturer (pool) overachieves its specific CO_2 emissions and/or LEV mandate, this would result in credits that could be sold to another manufacturer (pool), which would otherwise not meet its target.

[115] See Commission Implementing Decision (EU) 2016/2319 of 16 December 2016 confirming or amending the provisional calculation of the average specific emission of CO_2 and specific emissions targets for manufacturers of passenger cars for the calendar year 2015 pursuant to Regulation (EC) No 443/2009, OJ L 345, 20.12.2016, p. 74; Commission Implementing Decision (EU) 2016/2320 of 16 December 2016 confirming or amending the provisional calculation of the average specific emissions of CO_2 and specific emissions targets for manufacturers of new light commercial vehicles for the calendar year 2015 pursuant to Regulation (EU) No 510/2011, OJ L 345, 20.12.2016, p. 96

The main distinction compared to pooling is that trading would not require an upfront decision by manufacturers on how to ensure compliance with the target. The decision to trade could take place only at the time the provisional performance of the manufacturer (pool) is known.

Just as for pooling, trading would support the meeting of the CO_2 targets or a LEV mandate or a combination of both.

In the case of a LEV mandate (LEVT_MAND), different design options are possible, mainly in relation to how any LEV generating credits are being accounted for in relation to the CO_2 targets[116].

Under a LEV crediting system (options LEVT_CRED), a separation between LEV credits and CO_2 emission credits would not be necessary. For example, a manufacturer that does not achieve the LEV benchmark would have to meet a more stringent CO_2 target. If that leads to non-compliance with the CO_2 target, the manufacturer would have to buy credits from a manufacturer overachieving on its CO_2 target.

In light of the above the following options are considered:

- Option TRADE 0: Change nothing – no trading
- Option TRADE 1: Introduce trading as an additional modality for reaching the CO_2 targets and/or LEV mandates

  Under this option, individual manufacturers (or pools) (which do not benefit from a derogation) would be allowed to exchange CO_2 and/or LEV credits on an 'ad hoc' basis. This would require the establishment of a register to ensure full transparency and accountability of all transactions among manufacturers.

Trading would be allowed for cars and for vans separately (not amongst them).

5.4.4 Banking and borrowing (BB)

Banking and borrowing are mechanisms used in different regulatory environments setting policy targets for individual actors with the aim of increasing flexibility and therefore lowering the cost of compliance. The rationale is that the overall desired outcome should be achieved by a certain time, while acknowledging that the optimal route to that point may differ between actors.

For the LDV CO_2 legislation, banking would mean that when in a given year the average specific CO_2 emissions of a manufacturer (pool) are below its specific emissions target, the manufacturer (pool) can carry over the difference between its emissions and its target as CO_2 credits for future compliance purposes. In case its average specific CO_2 emissions exceed the specific emissions target in one of the following years, the manufacturer (pool) can offset these excess emissions with the 'banked' CO_2 credits from preceding year(s).

Borrowing would mean that, in a given year, a manufacturer (pool) could comply with its CO_2 target by 'borrowing' CO_2 credits, which have to 'paid back' in subsequent years.

In order to ensure that the EU-wide fleet CO_2 target set for a certain date is actually met, banking and borrowing needs to be limited. For the definition of such a limit, the timeline for the new CO_2 emissions target(s) (options TT, see Section 5.1.2) is critical.

[116] Element Energy (2016): "Towards a European Market for Electro-Mobility" (report for Transport & Environment)

If new targets are only set in discrete years (e.g. 2025 and/or 2030), it would be necessary to define a target trajectory against which emissions in the intermediate years would be compared for the purpose of granting credits. This would avoid that too many credits are accumulated before 2025, respectively 2030, which otherwise would allow a manufacturer (pool) to significantly exceed the target and hence undermine the intended CO_2 emission reductions for that time period. In case of annual CO_2 targets, these would, by definition, provide for such a trajectory.

However, even if a trajectory is set, there may still be a risk of too many credits being accumulated over time. In order to prevent this, banking could be limited to certain time periods (e.g. 2025-2030) or even to one year (e.g. 2025, when overachieving the applicable target or the trajectory). In the latter case, credits could only be used for compliance with the 2030 target. Finally, the use of banked credits could be limited to the year 2030 and no credits could be used after that year (assuming that a target will remain in place in subsequent years).

Links with the LEV incentives

In case of option LEVT_MAND, the above considerations would equally be valid in relation to the LEV mandate.

However, the situation is different in case of a LEV crediting system (options LEVT_CRED) where compliance assessment is based on the CO_2 target only and therefore already makes a link between the LEV benchmark and the CO_2 target. Hence, under that option, banking would only be necessary in relation to the CO_2 target.

In light of the above-mentioned considerations, the following options are considered:

- Option BB 0: Change nothing

  Under this option, no banking or borrowing would be allowed.

- Option BB 1: Banking only

  Under this option, banking of CO_2 and/or LEV credits would be allowed, but no borrowing.

- Option BB 2: Banking and borrowing:

  Under this option, both the banking and borrowing of CO_2 and/or LEV credits would be allowed.

5.4.5 Exemptions and derogations

The Cars and Vans Regulations acknowledge that CO_2 targets should be determined differently for smaller manufacturers as compared to larger ones, taking account of their capability to meet such standards. The Regulations therefore contain the following derogations:

- A *de minimis* exemption (cars and vans), which was introduced in the legislation in 2014 for manufacturers responsible for less than 1,000 newly registered vehicles per year. This exempts small manufacturers, in many cases SMEs, from meeting a specific CO_2 emissions target and hence from applying for a derogation, thus reducing administrative burden;

- Small volume derogations (cars and vans): manufacturers (or a group of connected undertakings) responsible for between 1,000 and 10,000 cars registered per year or between 1,000 and 22,000 vans registered per year can apply to the Commission for an individual target consistent with their reduction potential;

- Niche derogations (cars only): manufacturers (or a group of connected undertakings) responsible for between 10,000 and 300,000 cars registered per year can apply for an individual target in 2021, corresponding with a 45% reduction from their 2007 average emissions.

5.4.5.1 'De minimis' exemptions' and 'small volume' derogations

De minimis exemptions reduce compliance and administrative costs for small manufacturers which are in many cases SMEs. Since they are exempt from meeting a specific CO_2 target they have no compliance costs for adapting their vehicles to meet CO_2 standards. The evaluation study estimated that the exemption reduces the administrative burden for the eligible manufacturers by around € 25,000 per manufacturer. It also facilitates the market entry of new manufacturers whilst having no significant impacts on the CO_2 reductions of the overall EU vehicles fleet. During the public consultation, small car manufacturers underlined the importance of this exemption, with no other stakeholders questioning it.

The evaluation study also identified the small volume derogations as a potential weakness, but also confirmed that its impacts in this respect had been relatively small. Most stakeholders also supported this derogation regime, although some environmental NGOs and public authorities were opposed.

In 2015/2016, 23 car manufacturers benefitted from this derogation, 18 of which had less than 1,000 registrations and could thus have benefitted from the *de minimis* exemption (many small manufacturers continue to apply for derogations since EU derogations are required to avoid penalties when selling vehicles on the Swiss market). Without a derogation (or exemption) all of these car manufacturers would have exceeded their specific emissions target.

Six van manufacturers (or pools) applied for this derogation in 2015/2016, three of which had less than 1,000 vans registered in these years and were thus eligible for the *de minimis* exemption [117]. Four other manufacturers, which were eligible for the derogation, did not apply for it as they met their 'default' (Annex I) target.

In considering possible options, it does not appear appropriate to completely exempt this group of manufacturers from meeting any CO_2 targets in view of the emission reduction potential in this segment, including the introduction of alternative powertrains. On the other hand, applying the same targets as for large volume manufacturers, based on the limit value curve, would mean that the reduction effort imposed on the small volume manufacturers would be significantly higher compared to large volume manufacturers taking account of their capability to meet emission standards (e.g. smaller fleet, fewer models).

The options of complete exemption or applying the same targets as for large volume manufacturers are therefore not considered further.

While some manufacturers applying for the derogation have pointed to the administrative burden of the application procedure as an issue, it should be noted that the Commission is empowered to define the detailed provisions on the application procedure and assessment

[117] The three manufacturers with more than 1,000 van registrations were Jaguar Land Rover (18460 vans in 2015 and 7435 in 2016), Mitsubishi (pool) (16,167 vans in 2015 – and 17,431 in 2016), and Piaggio & C SPA (2,621 vans in 2015 and 2,966 in 2016),

criteria. These concerns can effectively be addressed through a simplification of the current applicable rules which are defined under comitology[118].

In view of the above, the impact assessment does not consider specific options to change the existing regime of *de minimis* exemptions and small volume manufacturers.

5.4.5.2 Niche derogations for car manufacturers (NIC)

The Cars Regulation allows a 'niche' car manufacturer to meet a fixed emission reduction percentage set in relation to its emissions in 2007 (25% reduction by 2015 and 45% by 2021) instead of the 'default' emission target according to the limit value curve (Annex I to the Regulation). It should be noted that the percentage emission reduction between the 2015 and 2021 'niche' derogation targets is the same as the one between the fleet-wide targets set in the Regulation for those years (130 g/km and 95 g/km, respectively).

In 2015/2016, eight manufacturers or pools were eligible for a niche derogation but only five have applied to the Commission. Four out of the eight[119] were below their 'default' (Annex I) specific emissions target in one or both years and so strictly speaking did not need a derogation to comply with the Regulation.

It results from the evaluation study that this derogation potentially weakens the delivery of CO_2 emissions reductions. If all of the eligible manufacturers would apply for the derogation, the number of cars covered could then increase by up to five times[120].

During the public consultation, car manufacturers supported the continuation of this derogation regime but a majority of environmental and transport NGOs as well as all consumer organisations were against it.

Taking into account those considerations, the following options will be considered:

- Option NIC 0: Change nothing

  This would mean maintaining the current provisions of the Cars Regulation. As a result, the 'niche' manufacturers would have to continue to comply after 2021 with the current derogation target, i.e. 45% reduction from their 2007 average emissions.

- Option NIC 1: Set new derogation targets for 'niche' manufacturers

  Under this option, new "niche" targets would be defined for the period post-2021 on the basis of the overall CO_2 reduction targets defined for the EU-wide fleet (TLC, see Section 5.1.1). The starting point for the 'niche' manufacturers would be their specific emission target for 2021. This approach would be in line with the reduction pathway set in the current Regulations between 2015 and 2021.

- Option NIC 2: Remove the 'niche' derogation

  Under this option, no 'niche' derogations would be foreseen. This would mean that the 'niche' manufacturers would be covered by the same rules as the larger manufacturers as regards the target levels (see Section 5.1.1.1), distribution of effort (see Section 5.2) and LEV/ZEV incentives (see Section 5.3.2).

[118] Commission Regulation (EU) No 63/2011 and Commission delegated Regulation (EU) No 114/2013.

[119] Volvo Corporation, Mitsubishi Motors Pool, Honda Motor Europe Pool (2015 and 2016) and, Tata Jaguar Land Rover Pool (2016 only)

[120] The evaluation study referred to the situation in 2013, where manufacturers that applied for the niche derogation had registered a total of 439,000 new cars.

5.5 Governance

The CO_2 emission targets for LDVs are set and enforced using as reference a standardised type approval test, taking place in a laboratory. This approach is used worldwide and allows for comparability, reproducibility, verifiability and planning certainty. The effectiveness of the targets in reducing CO_2 emissions in reality depends on the one hand on the representativeness of the test procedure with respect to average real-world driving, and on the other hand on the extent to which the vehicles placed on the market conform to the reference vehicles tested at type approval.

As highlighted in the evaluation report and in the opinion of the Scientific Advice Mechanism[121], it is widely accepted that the currently used NEDC laboratory test is no longer representative of today's driving conditions and vehicle technologies. Evidence taken from a number of sources indicates a growing divergence over the past years, up to around 40%, between the certified emissions and the emissions of vehicles driven on European roads[122].

Factors which have contributed to this divergence include: the deployment of CO_2 reducing technologies delivering more savings under test conditions than on the road; exploitation of flexibilities in the test procedure; growing deployment of untested energy consuming devices; driver independent circumstances like weather, road conditions or trip types; driving style and driving modes[123].

During the public consultation there was very strong support across all stakeholder groups for the Commission to explore the potential to further reduce the divergence between the test cycle and real world emissions. Only representatives of car manufacturers and one component supplier were against this. All stakeholder groups, except for car manufacturers, supported establishing additional driving tests to give values closer to real driving emissions.

Application of the WLTP, which is mandatory in the EU for all new car types from September 2017 and for all new cars and vans from September 2019, will result in more realistic CO_2 values.

However, the longer-term effectiveness of the shift to WLTP in closing the gap will depend on the extent to which it will remain representative of real-world driving circumstances and on the degree to which it is enforced, including via market surveillance instruments.

The following sections set out the options considered in relation to these two governance aspects.

121 Scientific Advice Mechanism (SAM): Closing the gap between light-duty vehicle real-world CO_2 emissions and laboratory testing. High Level Group of Scientific Advisors, Scientific Opinion No. 1/2016, https://ec.europa.eu/research/sam/pdf/sam_co2_emissions_report.pdf#view=fit&pagemode=none

122 ICCT (2016): From laboratory to road – a 2016 update of official and 'real-world' fuel consumption and CO_2 value for passenger cars in Europe, http://www.theicct.org/sites/default/files/publications/ICCT_LaboratoryToRoad_2016.pdf

123 JRC (2016): Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars, https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/review-use-factors-affecting-fuel-consumption-and-co2-emissions-passenger-cars

5.5.1 *Real-world emissions (RWG)*

The effectiveness of technologies applied to reduce the CO_2 emissions of vehicles is affected by the actual driving conditions. This effectiveness can therefore not be fully captured by a laboratory emissions test procedure, in particular given the rapid evolution of these technologies.

Therefore, it is generally accepted that the emissions determined through a test procedure differ from the actual emissions achieved in the real world[124]. As such, this is not problematic for designing CO_2 targets relying on type approval values, as long as the expected divergence between the test procedure and the real world emissions can be estimated correctly (see Annex 6). However, for the CO_2 targets to fulfil their objective, it is important that any remaining divergence under the test procedure does not increase over time.

This consideration also applies with regard to consumer information. Type approval values of CO_2 and fuel consumption are used by consumers to compare different vehicles' performance in terms of fuel efficiency. In order avoid that consumers are misled with regard to the performance of vehicles, information on how type approval values compare to real world values should be readily available. Easy access to real world fuel and energy consumption data should contribute to achieve that and would also be an important step towards increased transparency and rebuilding consumer trust in the automotive industry as well as in the type approval system.

The following two options are considered with a view to address both the need to verify and ensure the representativeness of the new test procedure and to provide consumers with robust real world data on vehicle CO_2 emissions and fuel consumption:

- Option RWG 0: Change nothing

  This option assumes that the new test procedure WLTP, its periodic revision and the (proposed) revision of the type approval testing[125] would be sufficient to ensure the representativeness of the test procedure over time, with a limited and stable divergence with respect to average real-world emissions. It also assumes that the CO_2 and fuel consumption data resulting from the WLTP test would be sufficient in terms of consumer information.

- Option RWG 1: Collection, publication, and monitoring of real world fuel consumption data

  This option considers two main complementary sources: firstly, the collection by manufacturers of real world fuel and energy consumption data from new vehicles and their publication on-line or by other easily accessible means. Secondly, the monitoring and assessment by the Commission of the manufacturer data and, if appropriate, from national sources, such as from periodic technical inspections, with a view to continuously evaluate the representativeness of the WLTP.

[124] 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)

[125] European Commission, 2016: Proposal for a Regulation of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, COM(2016) 031 final

The implementation of these measures would require an empowerment for the Commission to determine the conditions for the collection and publication of the data, inter alia taking into account relevant data protection requirements. This empowerment would enable the development of a methodology to access, monitor and evaluate on a regular basis the average real world CO_2 emissions of the new vehicle fleet (and/or sub-fleets thereof) and determine how that evolves in comparison to the corresponding type approval values. The findings based on that evaluation would be an essential element to be considered in a review of the WLTP test procedure and, where necessary, of the CO_2 emission standards.

These measures require the availability of relevant data on real world fuel and energy consumption which are described below.

Standardized 'fuel consumption measurement device'

The Commission is currently preparing an amendment, in the context of the type approval legislation, of the WLTP Regulation 2017/1151 to lay down an obligation for manufacturers to fit a standardized 'fuel consumption measurement device' in the new vehicles.

This measure is not covered as an option in this impact assessment as it concerns an obligation under type approval legislation through a comitology act. It should however be noted that the cost for cars to be equipped with standardised, accurate and accessible on-board fuel-consumption measurement devices is estimated to be very low - in the order of 1 euro per vehicle[126]. - and they already exist in today's vehicles[127,128,], but the information is not accessible Moreover, this enabling technology has already been mandated in California[129] as of 2019.

The data resulting from such fuel consumption measurements would provide a robust basis to verify the representativeness of the WLTP type approval emission values and monitor the gap. It would also provide consumers with reference real world data on the basis of which they can assess how their own fuel economy compares to the average real world fuel consumption. In addition, it would enable simplified on-road fuel consumption measurements on a large number of vehicles.

An empowerment would be required for the Commission to develop the necessary provisions for the collection of the data as well as for the conditions for access and publication. This approach is in line with the recommendation of the European Parliament (following the work of its EMIS Committee)[130], the opinion of the Scientific

---

[126] 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

[127] TNO (2010) Effects of a gear-shift indicator and a fuel economy meter on fuel consumption https://circabc.europa.eu/webdav/CircaBC/GROW/wltp/Library/WLTP/consumption_meter/121018_legislation/FCM%20-%20GSI%20efficiency%20(TNO).pdf

[128] TNO (2013) Fuel consumption meter requirements for light-duty vehicles – Final report https://publications.europa.eu/en/publication-detail/-/publication/ffa5ab82-0bc2-472f-af0c-9d0d82a6b91f

[129] CARB (2016) OBD II regulation, section 1968.2 of title 13, California Code of Regulations, as approved by OAL on July 25, 2016. https://www.arb.ca.gov/msprog/obdprog/section1968_2_clean2016.pdf

[130] European Parliament recommendation of 4 April 2017 to the Council and the Commission following the inquiry into emission measurements in the automotive sector (2016/2908(RSP))

Advice Mechanism[131], as well as the technical assessment by the Commission's Joint Research Centre (see Annex 6).

Other data sources

In the absence of standardised on-board fuel sensors, real-world fuel consumption data can be gathered via self-reporting platforms or fleet operators[132,133] even though such data are subject to inherent bias. The gap can also be estimated using a simulation software like the Green Driving Tool developed by the Commission's Joint Research Centre[134,135].

CO_2 measurements are also performed at type-approval (ex-ante) as part of the Real Driving Emissions (RDE) procedure for pollutant emissions introduced gradually as of 2017[136]. Their measurement is necessary to validate the procedure itself. However, there is no evidence to date for the degree of representativeness of these data with respect to corresponding ex-post average real-world driving emissions, and there is a risk of bias and inconsistency across the tested vehicle types (see Annex 6).

Other option considered: elaboration of an ex-ante CO_2 real-driving emissions procedure, including the determination of a not-to-exceed limit

In their response to the public consultation, some environmental and transport NGOs and car drivers associations suggested to develop a dedicated new RDE test protocol for CO_2 emissions using Portable Measurement Equipment Systems (PEMS). In addition, binding not-to-exceed limits for CO_2 emissions would be introduced. These not-to-exceed limits would be based on the difference between the emissions measured during the WLTP test cycle and the new RDE procedure for CO_2 emissions. This would add another level of compliance checking, in a similar way as for air pollutant emissions.

The feasibility of such an approach is highly uncertain due in particular to the high variability in the CO_2 emissions under real world conditions. RDE CO_2 test results are strongly influenced by external factors, such as temperature, humidity, and driving behaviour. Consequently, the test results cannot offer the precision needed for regulatory purposes, such as target setting, compliance checking or for imposing financial penalties.

(http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P8-TA-2017-0100&language=EN&ring=B8-2017-0177)

[131] Scientific Advice Mechanism (SAM)(2016) Closing the gap between light-duty vehicle real-world CO_2 emissions and laboratory testing. High Level Group of Scientific Advisors, Scientific Opinion No. 1/2016, https://ec.europa.eu/research/sam/pdf/sam_co2_emissions_report.pdf#view=fit&pagemode=none

[132] Tietge U. et al (2016), From Laboratory To Road - A 2016 Update Of Official And 'Real-World' Fuel Consumption And CO_2 Values For Passenger Cars In Europe (ICCT)

[133] Greene D.L. et al (2015), How Do Motorists' Own Fuel Economy Estimates, How Do Motorists' Own Fuel Economy Estimates Compare with Official Government Ratings? A Statistical Analysis, Baker Reports

[134] https://green-driving.jrc.ec.europa.eu

[135] Zacharof N-G, Fontaras G., Ciuffo B., Tsiakmakis S., Anagnostopoulos K., Marotta A., Pavlovic J. (2016). Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars. JRC100150.

[136] Commission Regulation (EU) 2017/1154, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R1154

In a laboratory test – such as the WLTP – such external factors can be controlled and the test values can as a consequence ensure the necessary legal certainty and precision[137].

Custom-tailored test protocols of individual manufacturers (or groups) may provide more realistic fuel consumption and CO_2 emission values than a laboratory test. They can provide useful information to consumers. However, such protocols rely on test data from a limited number of vehicle models and selected drivers, and make use of monitored real world emissions of these specific fleets. As a consequence, these test protocols are not exposed to the same variability or uncertainties as compared to a more generic protocol that would have to apply in an equivalent way and with similar accuracy to any vehicle on the EU market.

In view of the above, the elaboration of an EU-wide ex-ante CO_2 real-driving emissions procedure at type-approval, including the determination of a not-to-exceed limit for the purpose of target setting and compliance checking does not appear feasible and is therefore discarded from further analysis.

5.5.2 Market surveillance (conformity of production, in service conformity) (MSU)

As recommended by the European Parliament following the work of its EMIS Committee[138] and stressed by several consumer organisations and environmental NGOs[139], it is necessary to put in place the means to detect irregularities in the CO_2 and fuel consumption data.

Recent test campaigns performed by independent laboratories, have provided indications of CO_2 emission values deviating significantly from the values determined at type approval[140]. Such deviations may undermine the achievement of the reduction objectives, distort competition among manufacturers and undermine consumer confidence in the type approval fuel consumption data.

Type approval tests are performed on a vehicle, which is representative of a certain vehicle family. The CO_2 emissions of each vehicle produced that the manufacturer attributes to that family must conform to the emissions of the approved type. The manufacturer certifies this in a certificate of conformity which is issued as a condition for placing a vehicle on the market.

---

[137] Scientific Advice Mechanism (SAM): Closing the gap between light-duty vehicle real-world CO_2 emissions and laboratory testing. High Level Group of Scientific Advisors, Scientific Opinion No. 1/2016,
https://ec.europa.eu/research/sam/pdf/sam_co2_emissions_report.pdf#view=fit&pagemode=none

[138] European Parliament recommendation of 4 April 2017 to the Council and the Commission following the inquiry into emission measurements in the automotive sector (2016/2908(RSP))

[139] BEUC (2016): Urgent need for better oversight of cars – A consumer view on the Commission proposal on type approval and market surveillance, http://www.beuc.eu/publications/beuc-x-2016-052_smacca_beuc_typeapproval_marketsurveillance_positionpaper_final.pdf;
ICCT (2017): Market surveillance of vehicle emissions: Best-practice examples with respect to the European Commission's proposed type-approval framework regulation, http://www.theicct.org/sites/default/files/publications/PV-in-use-surveillance_ICCT-position-brief_13072017_vF.pdf

[140] Ministère de l'Environnement, de l'Énergie et de la Mer (2016): Rapport final de la commission indépendante mise en place par la Ministre Ségolène Royal après la révélation de l’affaire Volkswagen, http://www.ladocumentationfrancaise.fr/var/storage/rapports-publics/164000480.pdf;
TNO (2016): NEDC – WLTP comparative testing, TNO 2016 R11285, http://publications.tno.nl/publication/34622355/ZCzWY2/TNO-2016-R11285.pdf

Each year, Member States report the CO_2 emission values recorded in the certificates of conformity of the newly registered vehicles to the Commission. On that basis, the Commission determines the annual average specific emissions of a manufacturer for the purpose of checking compliance with the specific CO_2 emissions target.

For the CO_2 reduction objectives to be achieved, it is essential that the CO_2 emissions of the vehicles placed on the market conform to the type approved values.

Under the type approval legislation, the conformity of the CO_2 emissions is currently verified only at the stage of production. Some vehicles are selected from the production line by the manufacturer and tested to verify that the CO_2 emissions are in line with those of the approved type. If this is not the case, the manufacturer has to take measures to bring the vehicles to be produced into conformity or perform a new type approval test.

A procedure for verifying the CO_2 emissions of vehicles on the road, i.e. a so called in-service conformity test, is not yet in place. However, a proposal for setting up such a procedure is under discussion by the co-legislators[141]. In case in-service tests would not be retained in type approval legislation following the on-going co-decision process, an empowerment for the Commission to set up an independent testing of vehicles in use could be considered as part of this proposal.

In view of this, the following options are considered to ensure that the emissions of vehicles placed on the market continue to adequately reflect the CO_2 emissions determined at type approval, to minimise the risk of deviations occurring and, if they occur, to ensure that the consequences for the CO_2 reduction objectives can be adequately addressed.

- Option MSU 0: Change nothing

  This option would mean that the CO_2 monitoring provisions set out in the Cars and Vans Regulations[142] and the associated implementing legislation continue to apply. This allows the Commission to amend the CO_2 monitoring data reported by Member States where manufacturers have found and notified errors in that data[143]. The verification by a manufacturer is voluntary and there is no explicit obligation placed on either manufacturers or Member States to report to the Commission deviations found from the type approved CO_2 emission values.

- Option MSU 1: Obligation to report deviations and the introduction of a correction mechanism

  Under this option, an obligation would be introduced in the legislation requiring 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 inform of deviations from the type approved CO_2 emissions affecting the monitored CO_2 data.

  The monitoring data for a manufacturer would be corrected in those cases where serious deviations from the type approval values have been detected which cannot be technically or otherwise justified. The empowerment would allow the Commission to

[141] European Commission (2016): Proposal for a Regulation of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, COM(2016)031 final.

[142] Article 8 of the Cars and Vans Regulations

[143] See Article 8(5) of Regulation (EC) No 443/2009 and Article 8(6) of Regulation (EU) No 510/2011

define the way in which deviations may be detected and how these should be reported to the Commission as well as taken into account for the compliance checking. This could build on measures defined within the framework of the type approval legislation, or as an independent testing procedure to be defined under the CO_2 regulations.

6 WHAT ARE THE ECONOMIC/EMPLOYMENT, ENVIRONMENTAL AND SOCIAL IMPACTS OF THE DIFFERENT POLICY OPTIONS AND WHO WILL BE AFFECTED?

6.1 General methodological considerations

The quantification of the impacts, in particular as regards the target levels, distribution of effort and LEV incentives - see Sections 6.3.2, 6.4 and 0 - 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_2 emissions from cars and vans.

These cost curves, which show the CO_2 reduction potential and costs for over 80 technologies, were determined as part of a study[144] on which car manufacturers, suppliers and other stakeholders provided input and were extensively consulted. 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 near future, and also options that have been proposed or are under development that could feasibly be introduced to the marketplace in the 2020-2030 period. Starting from a detailed assessment of these technologies, a total of 252 cost-curves on a WLTP basis was generated for different combinations of powertrain type (conventional, PHEV, BEV, FCEV), vehicle segment (four size classes for cars and three for vans) and year (2015, 2020, 2025 and 2030).

In the preparation of the cost curves, which represent a cost-optimal combination of technologies to be fitted in the vehicles to reach specific CO_2 reduction levels, the possibility (or impossibility) to combine technologies has been duly taken into account, as has their pre-existing market penetration in the vehicles fleet, and overlaps in the CO_2 saving potential of technologies when combined into packages.

In addition, for the purpose of analysing the sensitivity of cost assumptions apart from the "medium" costs, a number of cost-curves were developed illustrating the impact of low and high technology cost estimates. These different cost estimates were calculated using a methodological approach developed and refined in consultation with stakeholders and a statistical model to assess the uncertainty in the future cost projections. The "medium" cost case represents the most likely scenario resulting from significant future technology deployment to meet post-2020 CO_2 targets. The projected future costs of BEV, PHEV and FCEV powertrains take into account economies of scale and potential rates of learning on the cost reduction of key components (i.e. notably batteries and fuel cells) in different market deployment scenarios. These costs have also been reviewed in the light of the more rapid than expected reductions in battery costs.

The PRIMES-TREMOVE model is used to project the evolution of the road transport sector. This model was consistently used for climate, energy and transport initiatives in the past, including for the 2016 Commission initiatives concerning the Effort Sharing Regulation (ESR), the Energy Efficiency Directive (EED), the Low-Emission Mobility Strategy, the Eurovignette Directive, as well as impact assessment on the Clean Vehicles Directive which was conducted in parallel. In addition, macro-economic models (GEM-E3, E3ME) and the DIONE model developed by the JRC have been used. All analytical models used are described in detail in Annex 4.

[144] Ricardo Energy and Environment (2016) Improving understanding of technology and costs for CO_2 reductions from cars and LCVs in the period to 2030 and development of cost curves (report for the European Commission, DG CLIMA)

The baseline used for this impact assessment builds on the "Reference Scenario 2016" (*Ref2016*)[145], which was used as the baseline for the ESR and EED proposals and the Low-Emission Mobility Strategy. In this scenario the market uptake of advanced technologies is estimated to remain rather low, not allowing for economies of scale, i.e. costs for these advanced technologies staying high.

The baseline includes a few policy measures adopted after the cut-off date of *Ref2016* (end of 2014). Furthermore, some further differentiation in the model assumptions was needed in view of new information from specific studies, in particular:

(1) Updated cost curves were used, as explained above. The new costs are lower than the costs used as assumptions in *Ref2016* and other previous analytical work performed with the PRIMES-TREMOVE model.

(2) Based on a recent JRC study[146] and other publications, a higher gap between emissions measured during NEDC testing and those in real driving conditions has been applied, on average about 37% for cars and 33% for vans[147].

(3) The transition from the NEDC to the WLTP test cycle has been factored in by converting NEDC to WLTP emission values, using conversion factors derived by the JRC for this purpose (see Annex 4.5). For conventionally fuelled vehicles, these conversion factors are 1.21 for cars and 1.30 for vans, with specific values depending on the segments and powertrains.

Finally, the latest set of data from monitoring the implementation of the Cars and Vans Regulations (2015) has been used to properly reflect the current fleet composition and the turn-over rate for cars.

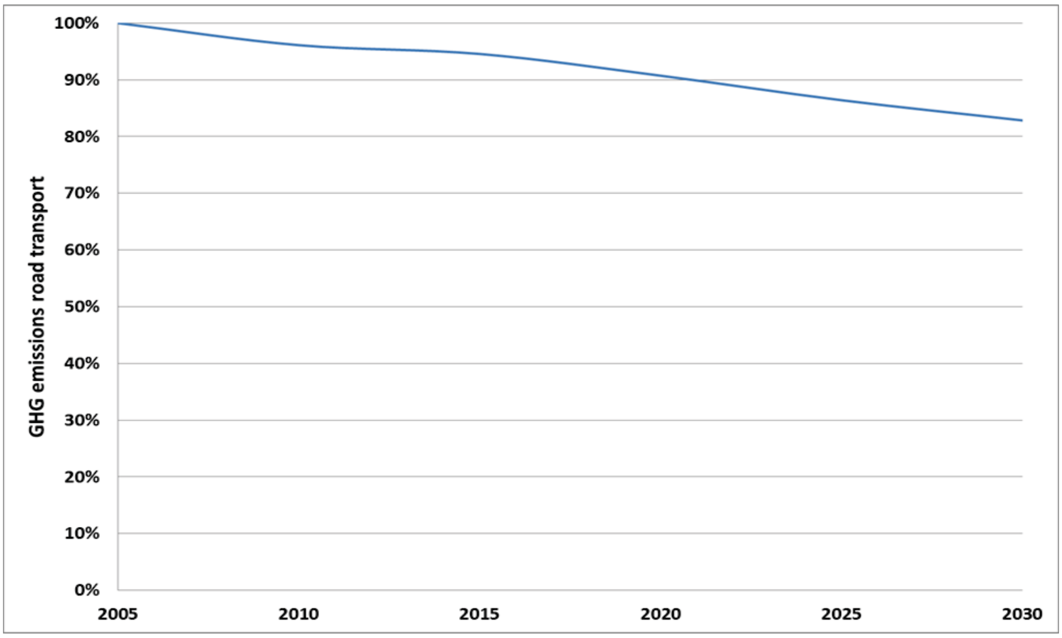
The baseline assumes that the EU-wide CO_2 standards for the new passenger cars and vans fleets remain at the same level as in the current Regulations after 2020/2021 (i.e. 95 g CO_2 /km for cars and 147 g CO_2/km for vans). This would lead to a reduction of CO_2 emissions in the period between 2020 and 2030 due to the renewal of the fleet and the reduction of the technology costs over time, which triggers the uptake of more efficient vehicles. However, in absence of new targets, the CO_2 emissions reductions remain limited. Figure 9 shows that the GHG emissions from road transport are expected to decrease by 17% in 2030 with respect to 2005.

[145] European Commission (2016) EU Reference Scenario 2016 - Energy, transport and GHG emissions : trends to 2050 (https://publications.europa.eu/en/publication-detail/-/publication/aed45f8e-63e3-47fb-9440-a0a14370f243)

[146] Zacharof N-G, Fontaras G., Ciuffo B., Tsiakmakis S., Anagnostopoulos K., Marotta A., Pavlovic J. (2016) Review of in use factors affecting the fuel consumption and CO_2 emissions of passenger cars. JRC100150.

[147] Taking into account the correlation factors applied between WLTP and NEDC, the average remaining gap between the WLTP emissions and the real driving emissions is about 13% for cars and about 3% for vans (specific values depend on the segments and powertrains).

Figure 9: Projected trend of greenhouse gas emissions from road transport between 2005 and 2030 under the baseline



In particular, CO_2 emissions from passenger cars and vans reduce by 26% and 17% respectively between 2005 and 2030. In a context of projected growing activity, these reductions are achieved due to the penetration in the fleet of more efficient vehicles. The monitored type-approval CO_2 values of new passenger cars and vans decrease respectively by 14% and 11% between 2020 and 2030.

The resulting composition of the new passenger car and van fleet in 2025 and 2030 is shown in Section 6.3.2.1 in Table 6 (TLC0) and Table 7 (TLV0). The uptake of LEV remains limited, especially when considering that by 2050 the fleet share of these vehicles should be around 68-72% in view of the longer term emission reduction objectives.

A detailed description of the baseline projections is presented in Annex 4.

6.2 Consistency with previous analytical work

A comparison was performed between different options for the CO_2 targets for new cars and vans considered for the period after 2020 in this impact assessment and under the "*EUCO30*" scenario[148], which is underlying several Commission climate, energy and transport policy proposals adopted in 2016. This scenario achieves the EU-wide 2030 targets regarding greenhouse gas emissions in the ESR sectors (a 30% reduction compared to 2005), and regarding final energy demand (27% renewable energy and 30% energy efficiency). The results are shown in Section 6.3.2.4.3 and in Annex 4.

[148] The *EUCO30* scenario is a key input to several Commission documents adopted in 2016: Impact Assessment underpinning the Proposal for the Effort Sharing Regulation, Staff Working Document accompanying the Communication on the low-emission mobility strategy, Impact Assessment accompanying the proposal for recast of the Directive on the promotion of energy from renewable sources, Impact Assessment accompanying the proposal for a revised Energy Efficiency Directive. (https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf)

6.3 Emission targets: metric, level and timing

6.3.1 Metric for expressing the targets

6.3.1.1 Option TM_WTW: metric for setting the targets based on Well-to-Wheel approach

The two main arguments most frequently used by stakeholders calling for a change from the current tank-to-wheel (TTW) to a well-to-wheel (WTW) metric mainly relate to the following aspects:

i. the need to account for the well-to-tank (WTT) emissions of electricity generation in comparison with those from fossil fuels, in particular in a context where the power sector is not yet fully decarbonised;

ii. the need to acknowledge the role of low-carbon fuels like bio-ethanol, bio-methane or synthetic fuels produced from renewable electricity when setting reduction targets for CO_2 emissions from cars and vans in order to incentivise the use of those fuels.

As regards the first argument, it needs to be remembered that greenhouse gas emissions from the power and refinery sectors in the EU are already covered by the EU emissions trading system (ETS). Furthermore, the power sector is also affected by measures to attain the Renewable Energy target.

With respect to the second argument, the Commission's 2016 RED-II proposal[149] sets mandates on the fuels sector for 2030. This means that EU policy is already in place for incentivising the deployment of renewable electricity and low-carbon fuels across all sectors, including transport.

Thus, moving to a WTW metric would *de facto* constitute double regulation for the fuels sector as well as the power sector. In the medium term, the impact of this double regulation on the emissions from those sectors in combination with other EU ETS sectors would likely be negligible as the total emissions of the EU ETS sectors are covered by a cap that declines every year. In fact, power sector emissions are reducing at a faster rate than that of any other sector**.** According to the projections based on the Reference Scenario 2016, about 65% of electricity generated in the EU in 2030 will be carbon free[150].

Projections taking into account newly proposed policies[151] show a carbon free share of more than 70%, and overall project a decrease of GHG intensity in the power sector of around 40% between 2015 and 2030. With the continuation of the linear reduction factor in the ETS beyond 2030, further reductions of the greenhouse gas intensity of the power sector will be realised. The WTW emissions of electric vehicles in particular can therefore be expected to reduce over time.

As the WTW emissions are not a property of the vehicle alone, it would be hard if not impossible to establish metrics which are accurate, fair and cost-effective. In fact, conventional powertrains are sufficiently flexible to use different fuel types within certain specifications and therefore it is not possible to determine ex-ante for a given new

---

[149] COM (2016) 767 final

[150] https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_ref2016_v13.pdf

[151] https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf

vehicle on which fuels it will actually run or to which extent these would be low-carbon fuels. PHEV and BEV will run on any form of electricity, no matter how it is produced, with PHEV also capable of running on liquid fuels. Hence, uncertain ex-ante assumptions would have to be used to account for the potential use of low-carbon fuels in the metric expressing the CO_2 emission performance.

Alternatively, some fuel producers propose to use an ex-post crediting approach for based on actual fuel use and the respective GHG emission factors. While it is theoretically possible to establish WTT factors for the many different fuels used in vehicles[152], there are numerous practical barriers to overcome to actually agree on such figures, which also vary geographically as well as over time. Lessons can be learned from the discussions regarding the monitoring requirements for upstream emissions in the context of the Fuel Quality Directive 98/70/EC (FQD), where stakeholder concerns about large administrative burden contributed to the political decision not to insist on detailed monitoring of emissions from well to tank and instead to discontinue regulating CO_2 in the FQD after 2020. Similarly, as in the implementation of the Renewables Directive the issues of indirect land use change (ILUC) and the sustainability of imported low-emission fuels would have to be addressed. For the WTW based CO_2 targets, the exact same issues would have to be faced, but in addition a discussion would be needed regarding electricity.

Even in the case of an ex-post crediting system, highly uncertain ex-ante assumptions would have to be made about the availability of such credits when setting new CO_2 targets for cars in order to maintain a sufficient level of incentives for accelerating the adoption of efficient and clean technologies in cars and vans.

As the actual emission reduction potential, the market availability and the penetration rate of low-emission fuels falls outside the direct control of the automotive industry, ACEA advocates maintaining the current tank-to-wheel metric.

Additional information on WTW emissions can be found in Annex 8.1.

6.3.1.2 Option TM_EMB: metric for setting the targets based on embedded emissions

Apart from the WTW emissions, which cover the use phase of the vehicle and the production of the fuels used, there are also "embedded" CO_2 emissions associated with vehicle manufacturing (including the mining, processing and manufacturing of materials and components), maintenance and disposal.

It is estimated that those embedded emissions currently cause around 16% of the total lifetime CO_2 emissions of EU cars[153]. Additional information on embedded emissions can be found in Annex 8.1.

---

[152] See e.g. the reports published by the JEC research collaboration between the Commission's Joint Research Centre , EUCAR (European Council for Automotive R&D) and CONCAWE (the Oil Companies' European Organisation for Environment, Health and Safety) - http://iet.jrc.ec.europa.eu/about-jec/downloads

[153] Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles, https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf; TNO (2015): Energie- en milieu-aspecten van elektrische personenvoertuigen, TNO 2015 R10386, http://publications.tno.nl/publication/34616575/gS20vf/TNO-2015-R10386.pdf; EEA (2016) Electric vehicles in Europe, https://www.eea.europa.eu/publications/electric-vehicles-in-europe; studyCE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

The evaluation study concluded that the further uptake of technologies improving the fuel efficiency of conventional (internal combustion engine) vehicles would have a limited impact on production emissions, and that the tailpipe CO_2 emission savings achieved through such measures would outweigh by far any additional production emissions.

Nevertheless, it was also noted that the relative importance of embedded emissions may increase in the long-term, in particular when the proportion of vehicles using alternative powertrains is increasing.

A number of recent studies highlighted the potential emissions associated with the production of batteries for electric vehicles. However, the emission factors calculated vary significantly depending on the type of battery in terms of materials and energy density and the source of energy used for its production[154]. Furthermore, it is anticipated that the significance of batteries in the overall carbon footprint of electric vehicles could decrease very significantly due a number of factors, including the anticipated increase in gravimetric energy density reducing the materials use per kWh, the reduced GHG intensity of the power sector (see above) and materials used in battery manufacture, improved recycling processes, and an extension of the battery lifetime. Improved overall vehicle efficiencies would also contribute to this by reducing the size of the battery needed for a given electric range. All of this would cause the GHG emissions from the lifecycle of a BEV to drop by 40% between 2020 and 2030, in particular, if combined with establishing a strong battery manufacturing base within the EU in the near future.

Another study[155] highlighted the technical complexity of the issue, and the high administrative burden of covering embedded emissions in a meaningful way. In addition, trade policy issues might be raised as in the case of the emissions from fuels produced from Canadian tar sands during the implementation of the FQD. Such highly complex and detailed emission reporting would need to rely on life-cycle assessment (LCA) reporting by manufacturers which would have to cover all relevant downstream emissions from a huge number of suppliers of materials and car parts within the EU and from third countries. Developing a meaningful and robust methodology with guidelines and tools would be lengthy and costly.

Using a pre-described LCA approach that is sufficiently meaningful and providing the right incentives for reducing the embedded emissions would not only be extremely complex in terms of methodological approach, but would also be very difficult to enforce.

If such a LCA methodology could not be established, fixed default values for including embedded emissions in the metric would have to be used. However, this would have very limited added value as it would just give incentives for reducing the amount of materials used, but not take account of the differences between the emissions related to various materials.

[154] For example: M. Romare & L. Dahllöf IVL) (2017) The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries; L. A.-W. Ellingsen et al. (2017) Identifying key assumptions and differences in life cycle assessment studies of lithium-ion traction batteries with focus on greenhouse gas emissions (Transportation Research Part D 55 (2017) 82–90); H.C. Kim et al. (2016) Cradle-to-Gate Emissions from a Commercial Electric Vehicle Li-Ion Battery: A Comparative Analysis (Environ. Sci. Technol. 2016, 50, 7715−7722)

[155] CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

In response to the public consultation, most car manufacturers were against covering embedded emissions in the metric, while other stakeholder groups had diverging views. The steel industry mentioned that the eco-innovation scheme should be complemented with an LCA credit option.

For the reasons above, including embedded emissions in the metric in a meaningful way is not deemed feasible with an effort proportionate to the expected benefits due to the technical complexity of the issue and the prohibitively high cost of data collection at the level of granularity required.

In the coming years, voluntary reporting on embedded emissions of the most relevant segments along the supply chain and testing various methodological approaches could offer further insights to manufacturers on the overall carbon footprint of car manufacturing. This could be combined with regularly monitoring the progress made with reducing the embedded emissions through dedicated studies.

6.3.1.3 Option TM_MIL: metric for setting the targets based on mileage weighting

Information on vehicle lifetime mileage was gathered in the context of two studies on behalf of the Commission. A first one[156] investigated differences in lifetime mileage between vehicle categories. A follow-up study[157] gathered additional data and analysed the total mileages of vehicles of different ages with the aim of describing how annual mileage varies and accumulates during the vehicle lifetime.

It was found that diesel cars on average run higher mileages than petrol cars, but no size-related differences in mileage were identified for vans.

Introducing mileage-weighting when calculating the fleet-wide average emissions, by weighting the CO_2 emissions of each type of car by the distance typically travelled over its lifetime, would impose a proportionately more stringent target on larger and heavier vehicles. According to the findings of the study, this would in turn slightly reduce by 1.6-1.8% the overall fleet-wide cost of achieving the same CO_2 reduction.

A main challenge encountered during these studies was to find appropriately detailed data at Member State level and important data gaps remain in this respect.

A more recent study[158], building on the aforementioned data, concluded that accounting for different lifetime mileages would have a relatively limited impact on the effectiveness, costs and competitiveness. Furthermore, it was highlighted that establishing robust and broadly agreeable mileage numbers for different vehicle types and categories depending on the utility value or other characteristics would be very complicated.

In light of the above, there are a number of uncertainties around the feasibility of establishing a robust mileage database to implement this option.

---

[156] Data gathering and analysis to assess the impact of mileage on the cost effectiveness of the LDV CO2 Regulations. (Ricardo-AEA, report for the European Commission (2014))

[157] Improvements to the definition of lifetime mileage of light duty vehicles (Ricardo-AEA, report for the European Commission (2015))

[158] CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

6.3.2 Target levels for cars (TLC) and vans (TLV)

6.3.2.1 Introduction

As regards the CO_2 emission performance of new passenger cars, due to the continuous overall improvement of car technologies some autonomous improvement is expected to occur under the baseline. On average, WLTP CO_2 emissions in 2030 are estimated to be 14% lower than in 2021. For vans, a similar effect is seen, bringing down emission by 10% in 2030 compared to 2020. In fact, the improvements already captured in the baselines TLC0 and TLV0 are very similar to the results of the options TLC10 and TLV10. Therefore, there is no need to consider the latter options further.

Table 6 and Figure 10 show the impact of the remaining six target options on the composition of the EU-wide fleet for passenger cars in 2025 and 2030.

At moderate target levels up to TLC30, the change in composition of the fleet will be rather gradual compared to the baseline. For instance, with a 30 % target the share of gasoline and diesel cars in 2030 will still make up almost three quarters of the total fleet, compared to slightly more than 80% in the baseline. Only at the higher target levels, the change would be more rapid. In the most ambitious scenario, the gasoline and diesel car share would decline to a little more than 55%.

It should be noted that for option TLC20 the new fleet composition results in an over-achievement of the CO_2 target constraint. This is because for all policy options, the introduction of the CO_2 target constraint is assessed in the context of the broader policy on low-emission mobility, i.e. in conjunction with enhanced availability of recharging infrastructure and better user acceptance of advanced powertrains as higher mileage of EVs reduces range anxiety. These factors result in an enhanced up take of more advanced power trains. In combination with cost-beneficial improvements of ICEVs, this leads to a situation that the 20% target is somewhat overachieved. This effect is also illustrated in the results regarding final energy demand (section 6.3.2.2.1.4) and CO_2 emission trends over time (section 6.3.2.4.1), where the TLC20 results are somewhat optimistic, when comparing the different policy options.

Table 6: Passenger car fleet powertrain composition (new cars) in 2025 and 2030 under different TLC options

2025	Gasoline		Diesel		CNG	LPG	PHEV	BEV	FCEV	Other
	ICEV	HEV	ICEV	HEV						
TLC0	27.3%	13.6%	36.3%	9.8%	1.7%	3.3%	4.8%	2.4%	0.4%	0.3%
TLC20	25.2%	13.8%	33.9%	9.6%	1.7%	3.5%	6.6%	4.1%	1.1%	0.5%
TLC25	24.9%	13.8%	33.6%	9.7%	1.7%	3.5%	6.9%	4.3%	1.1%	0.6%
TLC30	24.6%	13.8%	33.2%	9.8%	1.6%	3.6%	7.2%	4.4%	1.2%	0.6%
TLC40	22.4%	14.1%	31.6%	9.8%	1.6%	3.8%	9.1%	5.4%	1.5%	0.7%
TLC_EP40	20.1%	14.1%	30.0%	10.5%	1.5%	4.3%	10.7%	6.3%	1.7%	0.9%
TLC_EP50	19.4%	14.3%	29.3%	10.3%	1.5%	4.1%	11.6%	6.7%	1.9%	0.9%

2030	Gasoline		Diesel		CNG	LPG	PHEV	BEV	FCEV	Other
	ICEV	HEV	ICEV	HEV						
TLC0	23.8%	15.2%	33.5%	10.3%	1.8%	3.8%	6.7%	3.9%	0.7%	0.3%
TLC20	21.0%	15.6%	29.9%	9.9%	1.8%	3.9%	9.3%	6.4%	1.7%	0.6%
TLC25	20.4%	15.4%	29.1%	10.0%	1.8%	4.0%	10.0%	6.7%	1.8%	0.7%
TLC30	19.9%	15.3%	28.4%	10.1%	1.8%	4.1%	10.8%	7.1%	1.9%	0.7%
TLC40	16.7%	14.6%	24.4%	9.6%	1.6%	4.2%	15.7%	9.7%	2.6%	1.0%
TLC_EP40	15.7%	14.4%	22.9%	9.5%	1.5%	4.1%	17.4%	10.7%	2.8%	1.1%
TLC_EP50	13.3%	12.8%	20.1%	9.1%	1.4%	3.9%	22.1%	13.0%	3.3%	1.0%

Figure 10: Passenger car fleet powertrain composition (new cars) in 2025 and 2030 under different TLC options

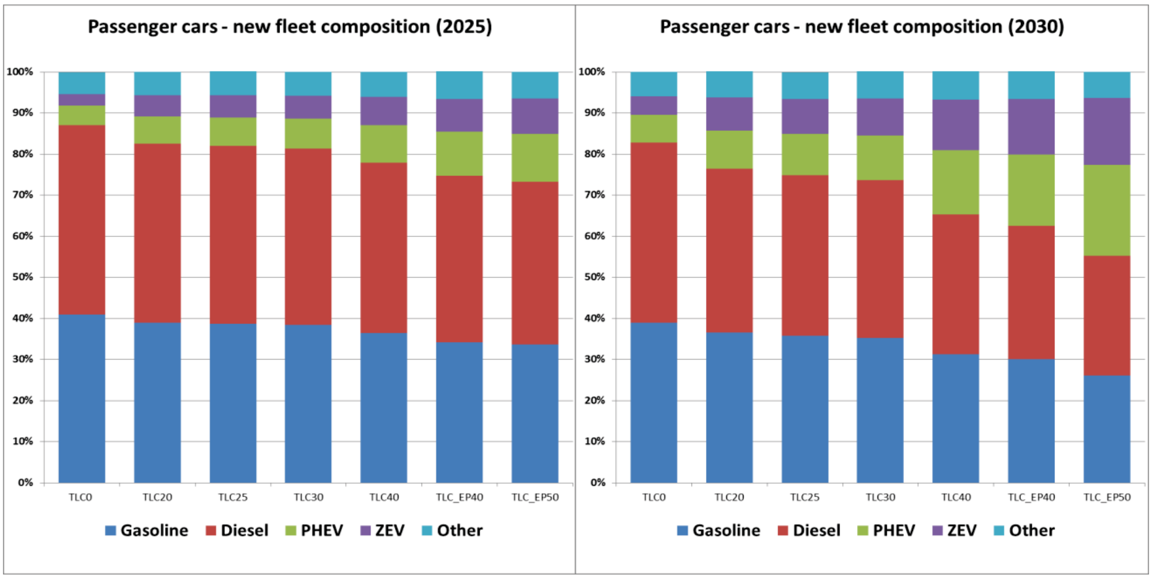


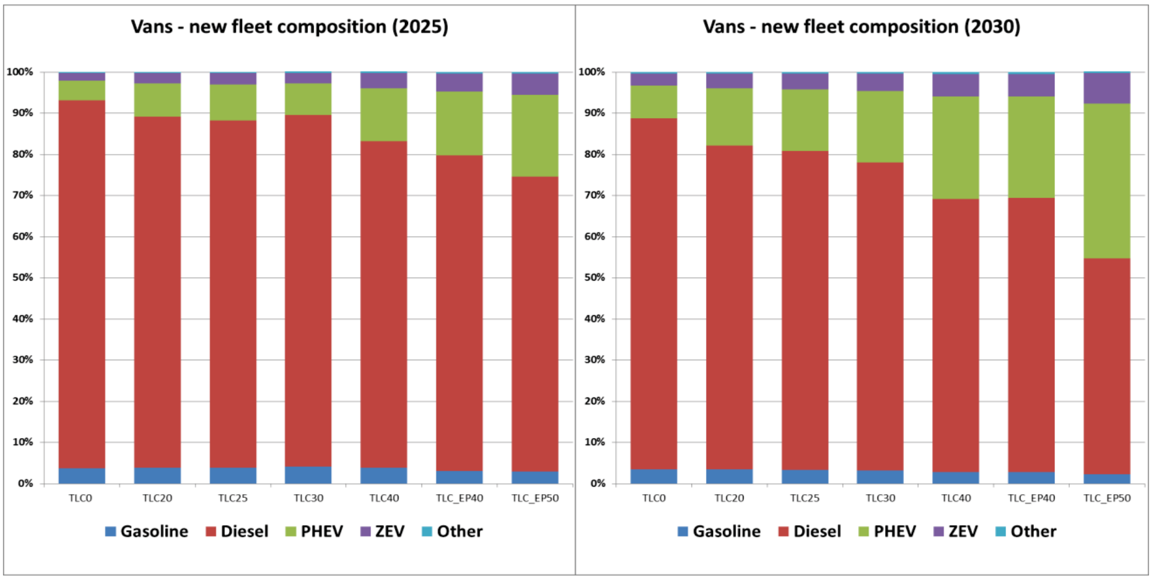
Table 7 and Figure 11 show the impact of different target level options on the composition of the EU-wide fleet of new vans in 2025 and 2030. This shows that for vans the change would be a little less pronounced than for cars. Under the 30% target, in 2030 almost four fifths of the vans would still be equipped with a more efficient combustion engine. At the highest level of ambition considered, this share would fall to a little less than 55%.

Table 7: Van fleet powertrain composition (new vans) in 2025 and 2030 under different TLV options

2025	Gasoline		Diesel		CNG	LPG	PHEV	BEV	FCEV
	ICEV	HEV	ICEV	HEV					
TLV0	2.2%	1.5%	57.3%	32.2%	0.2%	0.1%	4.7%	1.7%	0.1%
TLV20	2.1%	1.7%	53.4%	31.9%	0.2%	0.1%	8.1%	2.0%	0.5%
TLV25	2.1%	1.7%	53.7%	30.7%	0.2%	0.1%	8.8%	2.2%	0.5%
TLV30	2.1%	2.0%	54.4%	31.0%	0.2%	0.2%	7.7%	2.2%	0.4%
TLV40	1.9%	2.0%	49.3%	30.0%	0.2%	0.2%	12.8%	3.0%	0.7%
TLV_EP40	1.8%	1.3%	47.6%	29.1%	0.1%	0.3%	15.5%	3.5%	0.8%
TLV_EP50	1.7%	1.3%	44.1%	27.5%	0.1%	0.3%	19.9%	4.1%	1.0%

2030	Gasoline		Diesel		CNG	LPG	PHEV	BEV	FCEV
	ICEV	HEV	ICEV	HEV					
TLV0	2.0%	1.5%	53.2%	32.1%	0.2%	0.2%	7.9%	2.7%	0.2%
TLV20	1.9%	1.5%	48.6%	30.1%	0.2%	0.2%	14.0%	2.7%	0.8%
TLV25	1.9%	1.4%	47.5%	30.0%	0.2%	0.2%	15.0%	2.9%	0.9%
TLV30	1.8%	1.4%	45.6%	29.3%	0.2%	0.2%	17.3%	3.2%	1.0%
TLV40	1.6%	1.2%	40.4%	26.0%	0.2%	0.3%	24.8%	4.2%	1.3%
TLV_EP40	1.6%	1.2%	41.7%	24.9%	0.2%	0.3%	24.6%	4.2%	1.3%
TLV_EP50	1.3%	1.0%	32.5%	19.9%	0.1%	0.2%	37.6%	5.6%	1.9%

Figure 11: Van fleet powertrain composition (new vans) in 2025 and 2030 under different TLV options



6.3.2.2 Economic impacts (including employment)

In this section the following impacts are considered:

(i) Net economic savings from different perspectives

(ii) Energy system impacts

(iii) Macro-economic impacts, including employment

Net economic savings taking different perspectives

The direct economic impacts of the abovementioned options have been assessed by considering the changes (compared to the baseline) in capital costs, fuel costs[159], and operating and maintenance (O&M) costs for an "average" new vehicle (car or van), registered in 2025 or in 2030.

[159] The fuel costs are calculated taking into account the cost of electricity consumed in the electrically rechargeable vehicles. Both for the baseline and the different policy options the electricity prices as projected in the Reference Scenario 2016 are used.

An "average" new vehicle of a given year is defined by averaging the contributions of the different segments of small, medium, large vehicles and powertrains by weighting them according to their market penetration as estimated. The PRIMES-TREMOVE model projects the new fleet composition in a given year as a result of 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, gasoline, battery electric, plug-in hybrids, etc.) in the different market segments. The net savings for an "average" vehicle are calculated by averaging the costs and savings of the different powertrain types and segments, using the projected shares as weights. Since these shares change among the different scenarios, and they change for the new vehicles of 2025 and those of 2030, the cost indicators are used to represent the economic impacts for the new fleet of 2025 and 2030.

For this analysis, the following indicators have been used:

- Net economic savings over the vehicle lifetime from a societal perspective

  This parameter reflects the change in costs over the lifetime of 15 years of an "average" new vehicle without considering taxes and using a discount rate of 4%.

- Net savings from an end-user perspective, using two different indicators:
    - Total Cost of Ownership (TCO) over the vehicle lifetime (TCO-15 years)

  This parameter reflects the change in costs over the lifetime of 15 years of an "average" new vehicle. In this case, given the end-user perspective, taxes are included and a discount rate of 11% for cars or 9.5% for vans[160] is used.

    - TCO for the first user, i.e. net savings during the first five years after registration (TCO-first user):

  This parameter reflects the change in costs, during the first five years of use, i.e. the average time the first buyer is using the vehicle. Again, taxes are included and a discount rate of 11% for cars or 9.5% for vans is used. The calculation also takes account of the residual value of the vehicle and the technology added with depreciation.

Sensitivities

As explained in Section 6.1, apart from the cost curves based on the "Medium" technology cost estimates, a number of other cost-curves were developed as part of a sensitivity analysis. While the overall economic analysis of the policy options (TLC and TLV) relies on the use of the Medium costs, some sensitivities were run to investigate the effect on the net costs (savings) in case technology costs would decrease faster than anticipated under the Medium cost case. This additional assessment also allows looking into a situation where costs evolve differently for different powertrain types. This is particularly relevant for EV in view of the importance of the battery cell costs and the higher uncertainty over how these costs will evolve in the future very much depending on market penetration.

Two other sensitivities explored are related to the future oil price and to the evolution of the share of diesel cars in the fleet.

[160] https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_ref2016_v13.pdf

Energy system impacts

In view of the close link between the LDV CO_2 standards and energy use in the transport and fuel sectors, the energy system impacts have been analysed, considering the final energy demand, the final energy demand by energy source and the impact on the electricity system.

Macro-economic impacts

The broader macro-economic impacts of the different TL options have been analysed for the LDV sector (passenger cars and vans) as a whole. Therefore, the results are presented for cars and vans together in Section 6.3.2.2.3.

While the below Sections provide an overview of the main findings of the assessment and some illustrative tables and figures, the detailed results of the calculations of the net savings and their components are given in Annex 8.

6.3.2.2.1 Passenger cars (TLC)

6.3.2.2.1.1 Net economic savings over the vehicle lifetime from a societal perspective

Table **8** and Figure 12 show the net savings (EUR per vehicle, expressed as the difference with the baseline) over the vehicle lifetime from a societal perspective for an average new passenger car registered in 2025 and in 2030 under the different TLC options. The net savings observed are the result of differences in capital costs, fuel cost savings and O&M costs.

Capital costs – which in this case are equal to manufacturing costs - increase with stricter fleet-wide CO_2 target levels as reducing CO_2 emissions will require additional more expensive technologies to be implemented. For a car registered in 2025, the average additional capital cost ranges from 115 EUR (TLC20) to 1,411 EUR (TLC_EP40). In 2030, it ranges from 419 EUR (TLC20) to 2,752 EUR (TLC_EP50) per car.

At the same time, stricter targets will lower fuel costs as the fuel efficiency of the cars improves and more alternative powertrains are deployed, both measures reducing the amount of fuel consumed. Fuel cost savings per car range from 354 EUR (TLC20) to 1,394 EUR (TLC_EP40) in 2025 and from 1,159 EUR (TLC20) to 2,558 EUR (TLC_EP50) in 2030.

O&M costs show little variation between the different options, as they depend on the insurance and maintenance costs for the different segments and powertrains which compose the PRIMES-TREMOVE optimised fleet.

Both in 2025 and in 2030, net savings occur for options TLC20, TLC25, TLC30 and TLC40, ranging from 78 EUR (TLC40) to 152 EUR (TLC30) per car in 2025 and from 565 EUR (TLC40) to 902 EUR (TLC25) per car in 2030. Option TLC_EP40 results in net savings in 2030 (512 EUR per car), but not in 2025 (net costs of 42 EUR per car) while under option TLC_EP50 net savings are just below zero in both 2025 and 2030.

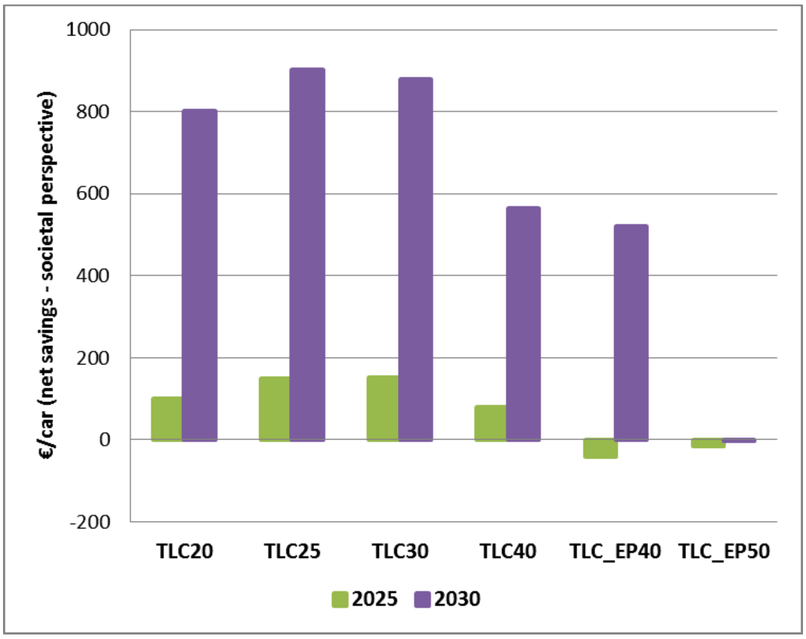
As can be seen from Table 8 and Figure 12, the highest net savings can be realised with options TLC25 and TLC30 in both 2025 and 2030.

Table 8: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/car)

2025 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	115	229	380	747	1,411	1,193
O&M cost [2]	139	139	130	96	25	22
Fuel cost savings [3]	354	514	661	922	1,394	1,198
Net savings [3]-[1]-[2]	*100*	*147*	*152*	*78*	*-42*	*-17*

2030 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	419	679	1,020	1,812	1,861	2,752
O&M cost [2]	-62	-62	-96	-157	-168	-192
Fuel cost savings [3]	1,159	1,520	1,802	2,220	2,214	2,558
Net savings [3]-[1]-[2]	*802*	*902*	*878*	*565*	*521*	*-2*

Figure 12: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/car)



In principle, in order to estimate the net economic savings over the vehicle lifetime from a societal perspective, one should include also the external benefits (or avoided external costs). For the options assessed here, the most important effect concerns additional benefits in terms of avoided CO_2 costs over the lifetime of a vehicle as compared to a baseline vehicle.

Table 10 gives an overview of the estimated additional avoided CO_2 costs for cars in 2030 for the different options assessed[161]. It shows that these external benefits increase as the CO_2 target gets stricter.

Table 10: Avoided CO_2 cost (EUR/car) over a car's lifetime

(EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Avoided CO_2 cost	303	375	451	593	609	728

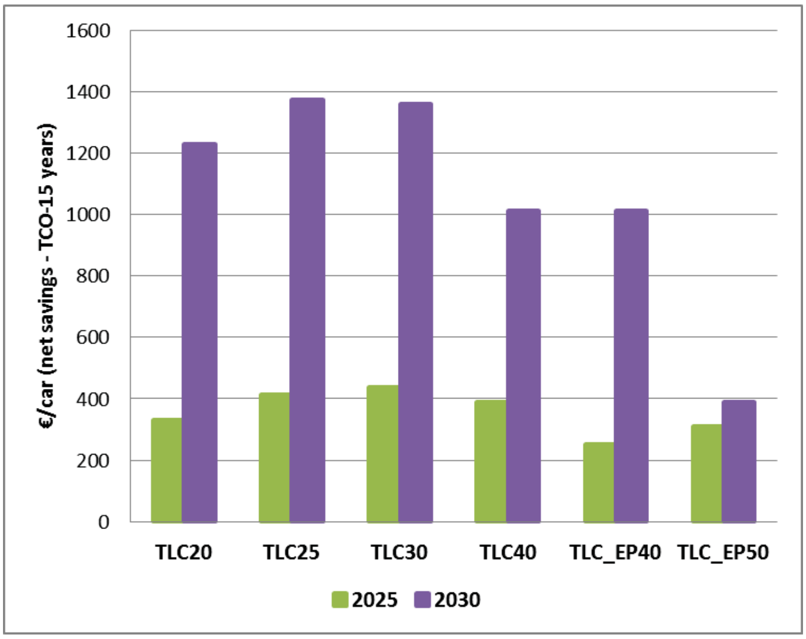
6.3.2.2.1.2 TCO-15 years (vehicle lifetime)

Figure 13 shows the TCO over 15 years (EUR per car) of an average new passenger car registered in 2025 and in 2030 under the different TLC options (expressed as the difference with the baseline).

It shows that in both years and under all options considered there are net savings for the end-users over 15 years. The savings per car in 2025 range from 253 EUR (TLC_EP40) to 436 EUR (TLC30) and they increase in 2030, ranging from 389 EUR (TLC_EP50) to 1,374 EUR (TLC25).

The highest net savings for the total cost of ownership over 15 years can be realised with a CO_2 target as in options TLC25 or TLC30.

Figure 13: TCO-15 years (vehicle lifetime) (net savings in EUR/car in 2025 and 2030)



6.3.2.2.1.3 TCO-first user (5 years)

Figure 14 shows the net savings (EUR per car) from a first end-user perspective for an average new passenger car registered in 2025 and in 2030 under the different TLC options (expressed as the difference with the baseline).

[161] The avoided CO_2 cost is based on the Update of the External Costs of Transport, with a value of 70 €/tonCO_2 for external costs of climate change, averaged over the period 2030-2045 (https://ec.europa.eu/transport/sites/transport/files/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf)

The trends seen are very similar to those found for the analysis from a societal perspective (see above).

Capital costs increase as the fleet-wide CO_2 target levels get stricter and range from 90 EUR (TLC20) to 1,104 EUR (TLC_EP40) for the average car registered in 2025. In 2030, they range from 328 EUR (TLC20) to 2,154 EUR (TLC_EP50) per car.

At the same time, stricter targets will lower fuel costs and fuel cost savings per car range from 348 EUR (TLC20) to 1,286 EUR (TLC_EP40) in 2025 and from 1,025 EUR (TLC20) to 2,354 EUR (TLC_EP50) in 2030.

O&M costs show little variation between the different options and are generally positive in 2025 and negative (i.e. lower than under the baseline) in 2030.

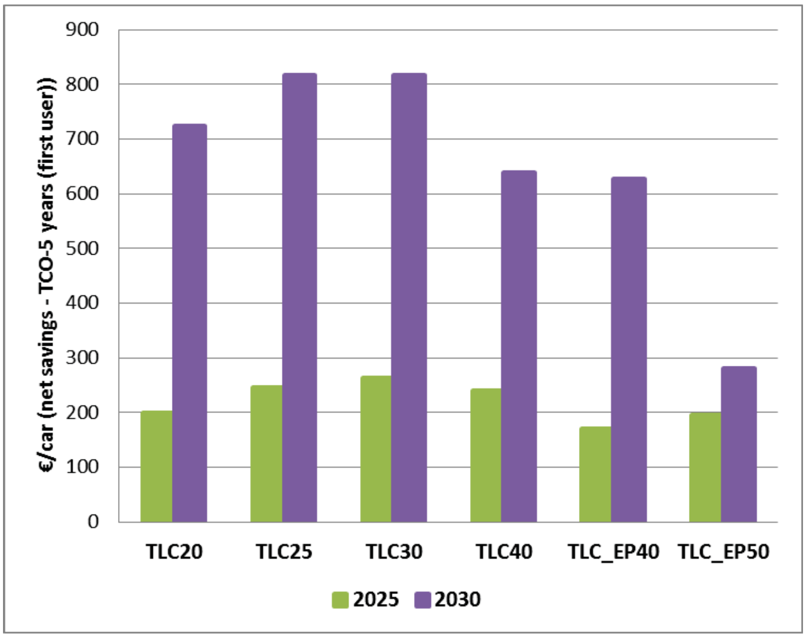
For the first user, both in 2025 and in 2030, net savings occur under all options considered, ranging from 171 EUR (TLC_EP40) to 263 EUR (TLC30) per car in 2025 and from 282 EUR (TLC_EP50) to 818 EUR (TLC30) per car in 2030.

The results of the following two sensitivities are given in Annex 8.2:

(i) sensitivity regarding the effect of varying cost assumptions;

(ii) sensitivity regarding the effect of a varying international oil price.

Figure 14: TCO-first user (5 years) (net savings in EUR/car in 2025 and 2030)



6.3.2.2.1.4 Energy system impacts

Figure 15 shows the impact of the different TLC options on the final energy demand for passenger cars over the period 2020-2040.

Under the baseline (TLC 0), the final energy demand for passenger cars is 170,300 ktoe in 2020 and it decreases over time as cars being subject to the CO_2 targets set in the current Cars Regulation enter the fleet. In 2030, the final energy demand for passenger cars is 13% lower than in 2020, and the effect of the current targets continues afterwards, i.e. in 2040 final energy demand is 16% lower than in 2020).

Under the different policy options regarding the CO_2 target level, the final energy demand for cars reduces further, and the effects of more stringent CO_2 targets become more outspoken from 2030 on as more and more cars which are subject to those targets enter the fleet.

The EU-wide fleet targets for CO_2 also affect the composition of the car fleet in terms of the powertrains used and hence have an impact on the demand per type of energy source in the transport sector.

Figure 16 shows the share of different fuel types used in the entire passenger car fleet (i.e. not only the newly registered cars) in 2025 and 2030. Diesel and gasoline by far remain the main fuels used in 2025 and 2030. Even for the most ambitious target level, there is only a gradual shift away from fossil to alternative fuels, in particular electricity and hydrogen. The shift is more outspoken in 2030 and for the options with more stringent CO_2 targets. For the other fuel types (biogasoline, biodiesel, gaseous fuel), there are very limited changes amongst the different options considered.

Figure 15: Final energy demand (ktoe) for passenger cars over the period 2020-2040 under different TLC options

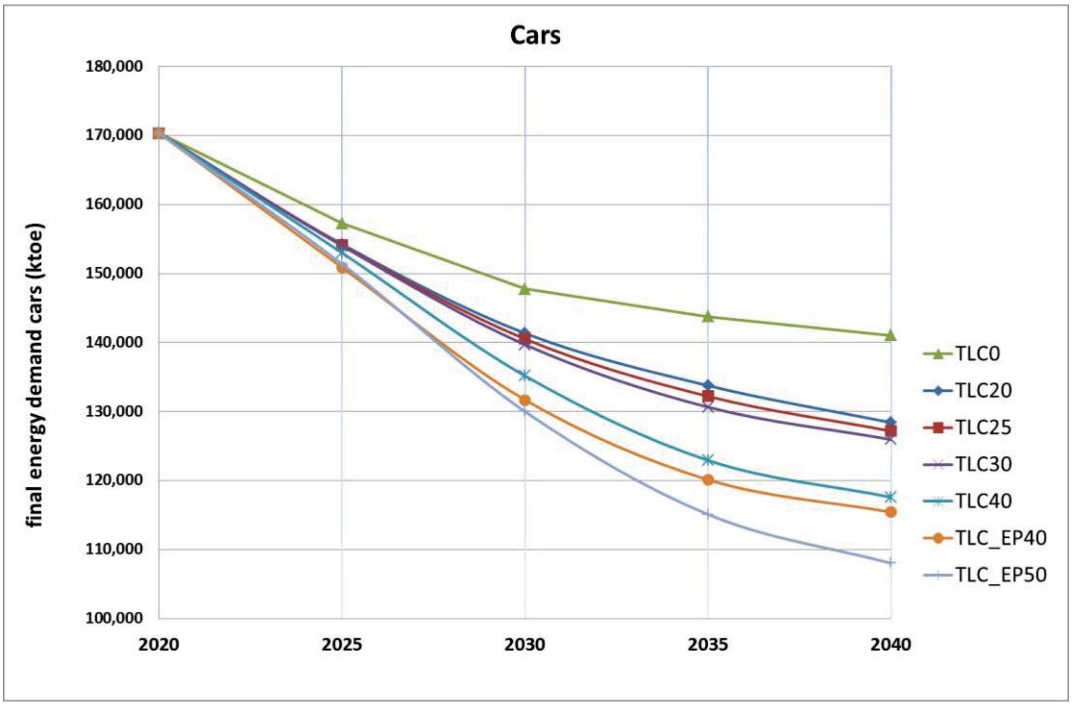
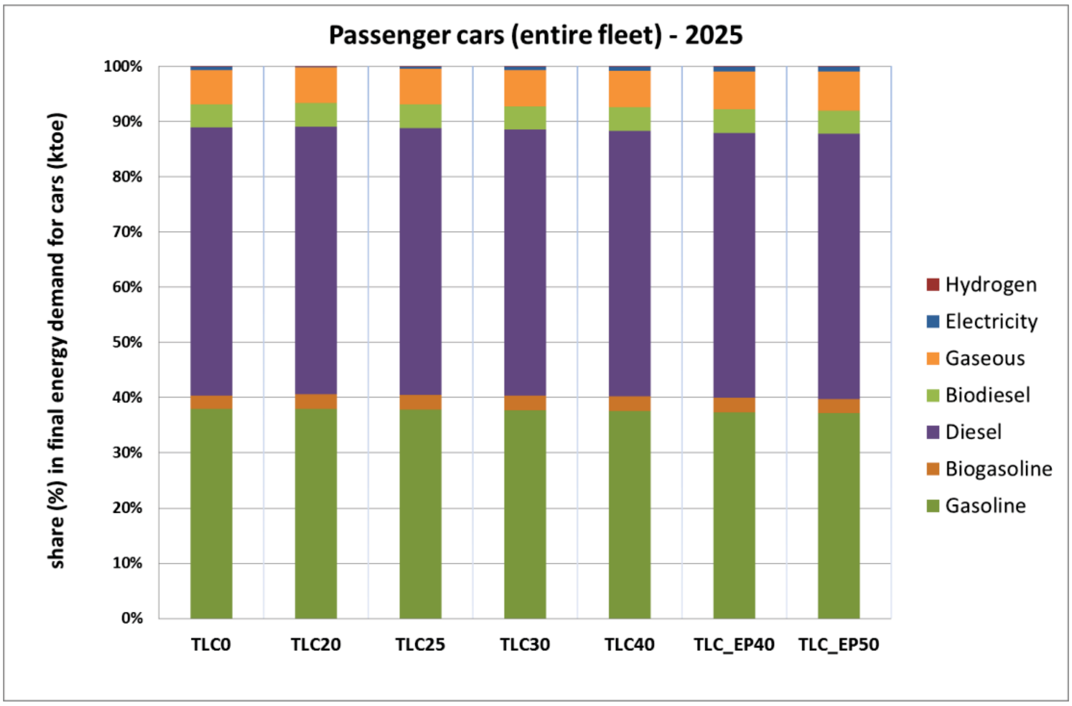
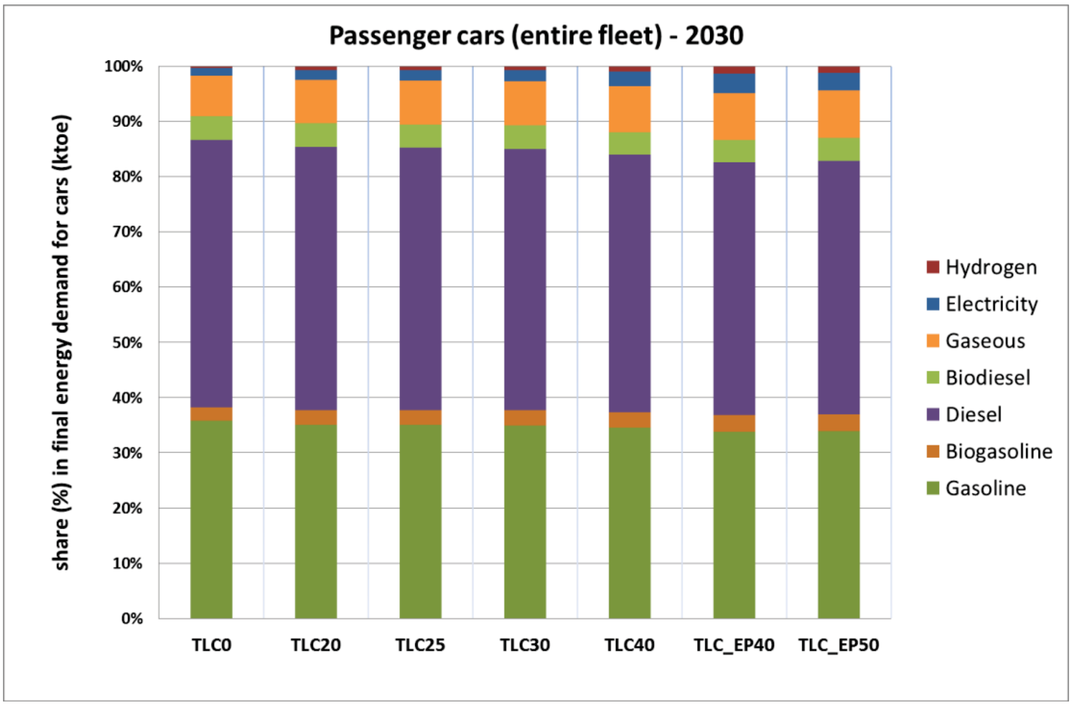


Figure 16: Share (%) of different fuel types in the final energy demand for cars (entire fleet) under different TLC options - 2025 and 2030





Electricity consumption

Table 9 shows the share of the total EU-28 electricity consumption used by cars and vans (together) in 2025 and 2030 for different CO_2 target level options. It illustrates that, even with the strictest targets considered, the share of electricity used by light-duty vehicles up to 2030 is not more than a few percent.

Table 9: Electricity consumption by cars and vans with respect to total electricity consumption (EU-28) under different options for the EU-wide CO_2 target levels

Options for the EU-wide CO_2 target level		Share of cars and vans in total electricity consumption	
cars	vans	**2025**	**2030**
TLC20	TLV20	0.5%	1.2%
TLC30	TLV25	0.5%	1.3%
TLC40	TLV40	0.5%	1.7%
TLC_EP50	TLV_EP50	0.6%	2.2%

Diesel and gasoline demand

Table 10 shows the cumulative savings of diesel and gasoline in the period 2020 to 2040 with respect to the baseline for different scenarios. Considering the combination of options TLC30 and TLV40, the cumulative savings between 2020 and 2040 are equivalent to around 150 billion euros at current oil prices

Table 10: Cumulative diesel and gasoline savings (Mboe) over the period 2020 to 2040 under different policy options with respect to the baseline

cars	**(Mboe)**	**vans**	**(Mboe)**
TLC20	1,881	TLV20	485
TLC30	2,136	TLV25	505
TLC40	2,864	TLV40	719
TLC_EP40	3,283	TLV_EP40	753
TLC_EP50	3,658	TLV_EP50	933

Sensitivity – effect of decreasing share of diesel cars

In view of recent developments following the diesel emission scandal and the persistent air quality issues in a number of cities across the EU, the share of diesel cars in the fleet of newly sold cars has declined in a number of EU Member States[162].In order to assess the potential effects, two sensitivities were designed with lower diesel car fleet shares, as shown in Table 11.

Table 11: Share of diesel cars (incl. diesel hybrids) in the new car fleet under the two "Low Diesel" sensitivities - % reduction compared to the baseline

Scenario	**Car segment**	**2025**	**2030**
Diesel_1	Small	20%	40%
	Medium	15%	30%
	Large	15%	30%

[162] ICCT (2017): Cities driving diesel out of the European car market, http://www.theicct.org/blogs/staff/cities-driving-diesel-out-european-car-market

Diesel_2	Small	40%	80%
	Medium	30%	60%
	Large	30%	60%

The resulting fleet composition under these two sensitivities is shown in Table 12, compared with the fleet composition in case of TLC25 and TLC30. It makes clear that diesel cars are largely substituted by gasoline cars with rather limited increases in PHEV, BEV and other (gaseous fuel) cars.

Table 12: Passenger car fleet composition in 2025 and 2030 under the "Low Diesel" sensitivities compared to options TLC25 and TLC30

2025	diesel	gasoline	PHEV	BEV	FCEV	other
TLC25	43%	39%	7%	4%	1%	6%
TLC30	43%	38%	7%	4%	1%	6%
Diesel_1	37%	43%	8%	5%	1%	6%
Diesel_2	29%	49%	8%	5%	1%	7%

2030	diesel	gasoline	PHEV	BEV	FCEV	other
TLC25	39%	36%	10%	7%	2%	6%
TLC30	39%	35%	11%	7%	2%	7%
Diesel_1	28%	43%	12%	7%	2%	7%
Diesel_2	13%	55%	13%	8%	2%	9%

Table 13 shows the resulting tailpipe CO_2 emission reductions for cars between 2025 and 2040, taking 2005 as the reference year, under the "Low Diesel" scenarios in conjunction with the EU-wide fleet CO_2 target of option TLC30. It shows that the impact of the declining diesel share is limited. CO_2 is reduced only slightly less than under option TLC30 when using the initial fleet composition. This is due to the modelled gap between test cycle and real-world emissions, which is slightly lower for diesel cars compared to gasoline cars. Therefore, a declining share of diesel cars leads to a small overall increase in the gap between type approval and real world emissions, hence a lower emissions reduction.

Table 13: (Tailpipe) CO_2 emissions of passenger cars in EU-28 - % reduction compared to 2005

	2025	2030	2035	2040
TLC30	22.0%	31.0%	41.3%	51.5%
Diesel_1	21.9%	30.5%	40.8%	50.6%
Diesel_2	21.9%	30.1%	40.1%	49.2%

In terms of economic impacts, the three tables below show that net savings from a societal perspective, vehicle lifetime perspective and first-user perspective decrease as diesel shares are declining. This is mainly due to a decrease in the fuel savings when the market shares of diesel car decrease. However, from any of the three perspectives there will still be significant net savings, especially when approaching 2030.

Table 14: Net economic savings from a societal perspective (EUR/car)

	TLC30	**Diesel_1 (TLC30)**	**Diesel_2 (TLC30)**
2025	154	77	34
2030	876	808	805
	TLC25	**Diesel_1 (TLC25)**	**Diesel_2 (TLC25)**
2025	147	25	-47
2030	902	758	749

Table 15: TCO– lifetime (15 years) – net savings in EUR/car

	TLC30	**Diesel_1 (TLC30)**	**Diesel_2 (TLC30)**
2025	438	251	51
2030	1,359	1,133	908
	TLC25	**Diesel_1 (TLC25)**	**Diesel_2 (TLC25)**
2025	413	170	-19
2030	1,374	1,038	739

Table 16: TCO- first user (5 years) – net savings in EUR/car

	TLC30	**Diesel_1 (TLC30)**	**Diesel_2 (TLC30)**
2025	263	149	23
2030	818	673	505

6.3.2.2.2 Light commercial vehicles (TLV)

6.3.2.2.2.1 Net economic savings over the vehicle lifetime from a societal perspective

Table 17 and Figure 17 show the net savings over the vehicle lifetime from a societal perspective for an average new van registered in 2025 and in 2030 under the different TLV options (expressed as the difference with the baseline).

Capital costs – which in this case equal manufacturing costs - increase with stricter EU-wide fleet CO_2 target levels as reducing CO_2 emissions will require additional more expensive technologies to be implemented. For a new van registered in 2025, the average additional capital cost ranges from 232 EUR (TLV20) to 1,469 EUR (TLV_EP50). In 2030 (when stricter targets apply), it ranges from 426 EUR (TLV20) to 2,439 EUR (TLV_EP50) per van.

At the same time, stricter targets will lower fuel costs and fuel cost savings per van range from 1,002 EUR (TLV20) to 2,529 EUR (TLV_EP40) in 2025 and from 2,063 EUR (TLV20) to 4,261 EUR (TLV_EP50) in 2030.

O&M costs show little variation between the different options, apart from TLV_EP50, where these costs are significantly lowered in 2030.

Both in 2025 and in 2030, net savings occur under all options, ranging from 810 (TLV20) to 1,369 EUR (TLV_EP40) per van in 2025 and from 1,687 EUR (TLV20) to 2,386 EUR (TLV40) per van in 2030.

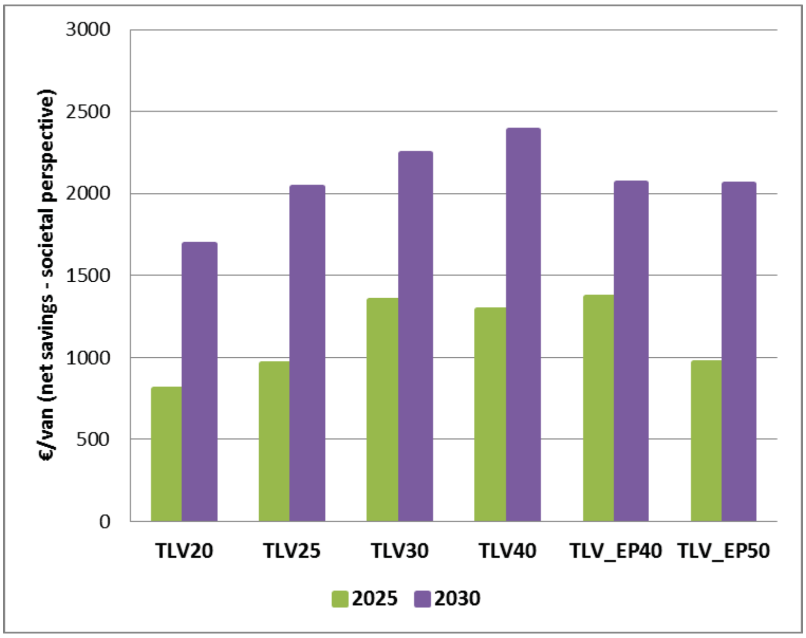
Overall, net savings for vans are significantly higher than for cars under options with similar emission target reduction percentages due to the much higher fuel cost savings achieved as vans start reducing from a significantly higher CO_2 efficiency standard. Importantly, the highest benefits occur at target levels of 30% and 40% in 2030. This could help improving the competitiveness of many SMEs.

Table 17: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/van)

2025	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Capital cost [1]	232	355	393	877	1,251	1,469
O&M cost [2]	-40	-52	-58	-106	-91	-119
Fuel cost savings [3]	1,002	1,265	1,685	2,061	2,529	2,316
Net savings [3-1-2]	*810*	*962*	*1,350*	*1,290*	*1,369*	*967*

2030	TLV20	TLV25	TLV30	TLV40	TLV_EP 40	TLV_EP50
Capital cost [1]	426	620	891	1,582	1,415	2,439
O&M cost [2]	-50	-55	-75	-142	-141	-239
Fuel cost savings [3]	2,063	2,600	3,064	3,827	3,341	4,261
Net savings [3-1-2]	*1,687*	*2,036*	*2,247*	*2,386*	*2,067*	*2,060*

Figure 17: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/van)



In principle, in order to estimate the net economic savings over the vehicle lifetime from a societal perspective, one should include also the external benefits (or avoided external costs). For the options assessed here, the most important effect concerns additional benefits in terms of avoided CO_2 costs over the lifetime of a vehicle as compared to a baseline vehicle.

Table 18 gives an overview of the estimated additional avoided CO_2 costs for vans in 2030 for the different options assessed[163]. It shows that these external benefits increase as the CO_2 target gets stricter.

Table 18: Avoided CO_2 costs over a van's lifetime

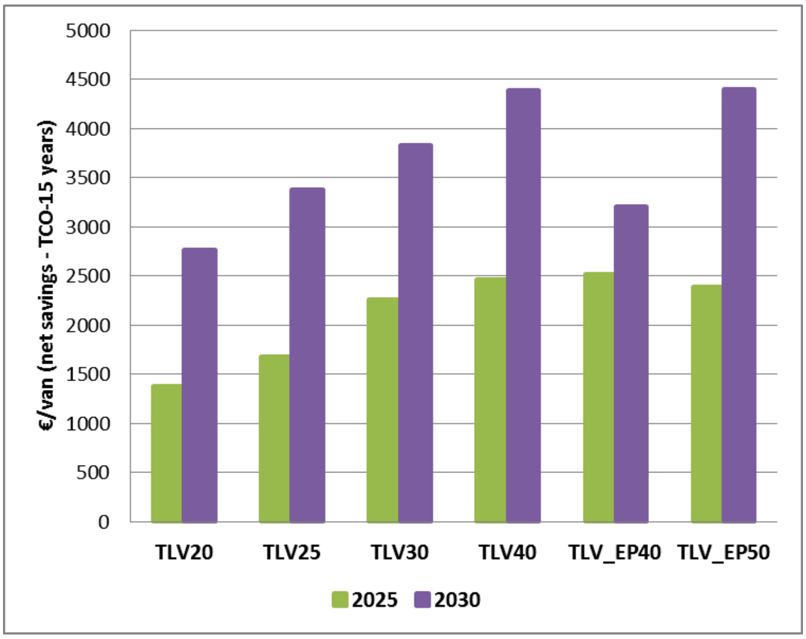
(EUR/van)	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Avoided CO_2 cost	521	649	774	1,000	898	1,212

6.3.2.2.2.2 TCO-15 years (vehicle lifetime)

Figure 18 shows the net savings in the total cost of ownership of an average new van registered in 2025 and in 2030 under the different options expressed as the difference with the baseline.

It shows that under all options considered there are net savings for the end-users over 15 years. The savings per van range from 1,382 EUR (TLV20) to 2,521 EUR (TLV_EP40) in 2025 and further increase in 2030, ranging from 2,765 EUR (TLV20) to about 4,400 EUR (TLV_EP50 and TLV40). The highest benefits occur at 30%, 40% and even 50% target reduction levels.

Figure 18: TCO-15 years (vehicle lifetime) in 2025 and 2030 (net savings in EUR/van)



[163] The avoided CO_2 cost is based on the Update of the External Costs of Transport, with a value of 70 €/tonCO_2 for external costs of climate change, averaged over the period 2030-2045 (https://ec.europa.eu/transport/sites/transport/files/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf)

6.3.2.2.2.3 TCO-first user (5 years)

Figure 19 shows the net savings from a first end-user perspective for an average new van registered in 2025 and in 2030 under the different TLV options (expressed as the difference with the baseline).

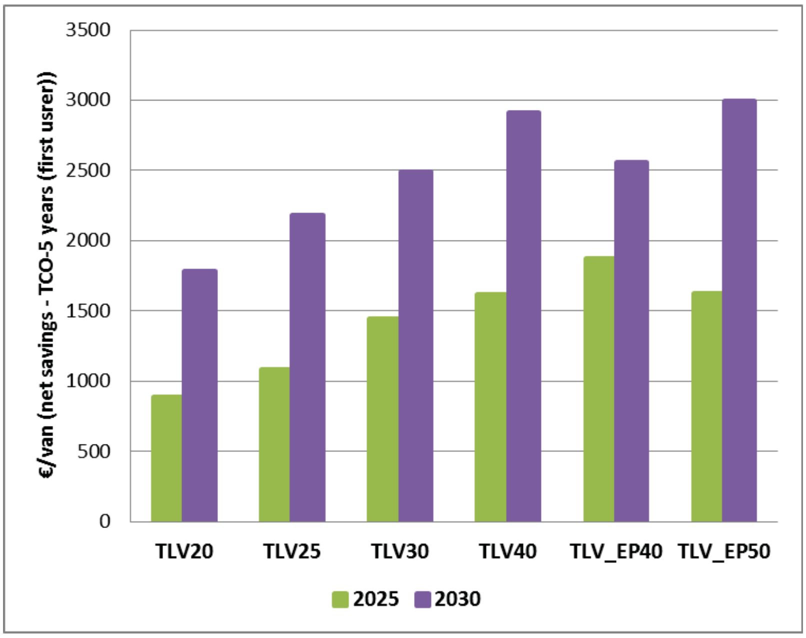
The trends are very similar to those found for the analysis from a societal perspective (see section 6.3.2.2.2.1). Capital costs increase as the fleet-wide CO_2 target levels get stricter and range from 144 EUR (TLV20) to 913 EUR (TLV_EP50) for an average van registered in 2025. In 2030, they range from 265 EUR (TLV20) to 1,516 EUR (TLV_EP50) per van.

At the same time, stricter targets will lower fuel costs for the end-user and fuel cost savings per van range from 1,016 EUR (TLV20) to 2,614 EUR (TLV_EP40) in 2025 and from 2,026 EUR (TLV20) to 4,412 EUR (TLV_EP50) in 2030.

O&M costs show relatively little variation between the different options and are always negative (i.e. lower than under the baseline).

As a result, both in 2025 and in 2030, the first user benefits from significant net savings under all options considered, ranging from 889 EUR (TLV20) to 1,702 EUR (TLV_EP40) per van in 2025 and from 1,783 EUR (TLV20) to 3,000 EUR (TLV_EP50) per van in 2030. The highest net benefits will be achieved at the higher end of the reduction targets.

Figure 19: TCO-first user (5 years) in 2025 and 2030 (net savings in EUR/van)



Light commercial vehicles are predominantly used by businesses, particularly SMEs. The total cost of ownership is therefore of particular importance for these companies. The above calculations show that SMEs could benefit from significant net savings both over the first five years of ownership as well as over the entire vehicle's lifetime.

The results of the following two sensitivities are given in Annex 8:

(i) sensitivity regarding the effect of varying cost assumptions;

(ii) sensitivity regarding the effect of a varying international oil price.

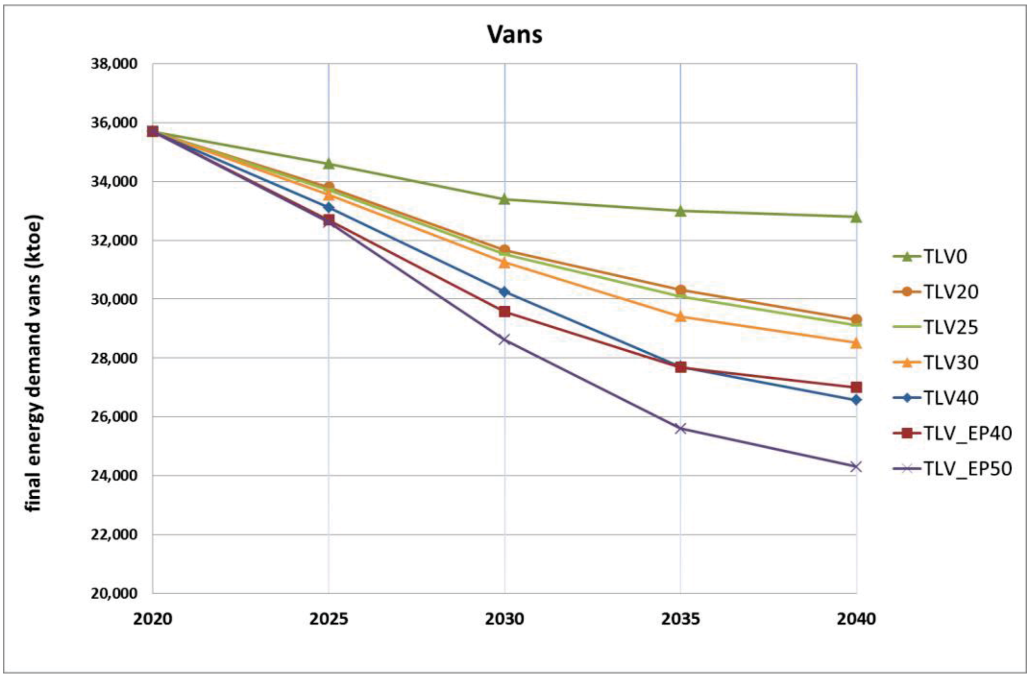
Energy system impacts

Figure 20 shows the impact of the different van CO_2 target level options on the final energy demand for vans over the period 2020-2040.

Under the baseline (TLV 0), the final energy demand for vans is 35,700 ktoe in 2020 and it decreases over time as new vans, which are subject to the CO_2 target set in the current Vans Regulation, enter the fleet. In 2030, the final energy demand for vans is estimated to be 6% lower than in 2020, but the effect of the current CO_2 target decreases afterwards. In 2040 final energy demand is 8% lower than in 2020.

Under the different TLV policy options, the final energy demand for vans is significantly lower compared to the baseline. The effects of more stringent CO_2 targets becomes even more pronounced from 2030 onward as more and more new vans which are subject to those targets enter the fleet.

Figure 20: Final energy demand (ktoe) for vans over the period 2020-2040 under different TLV options

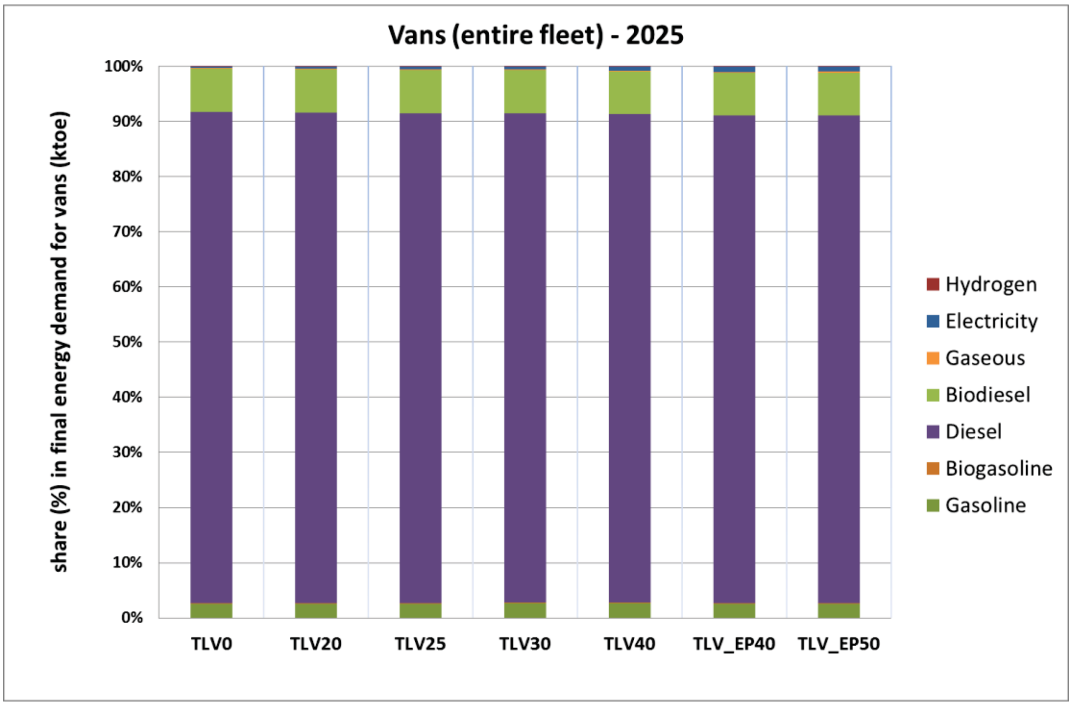


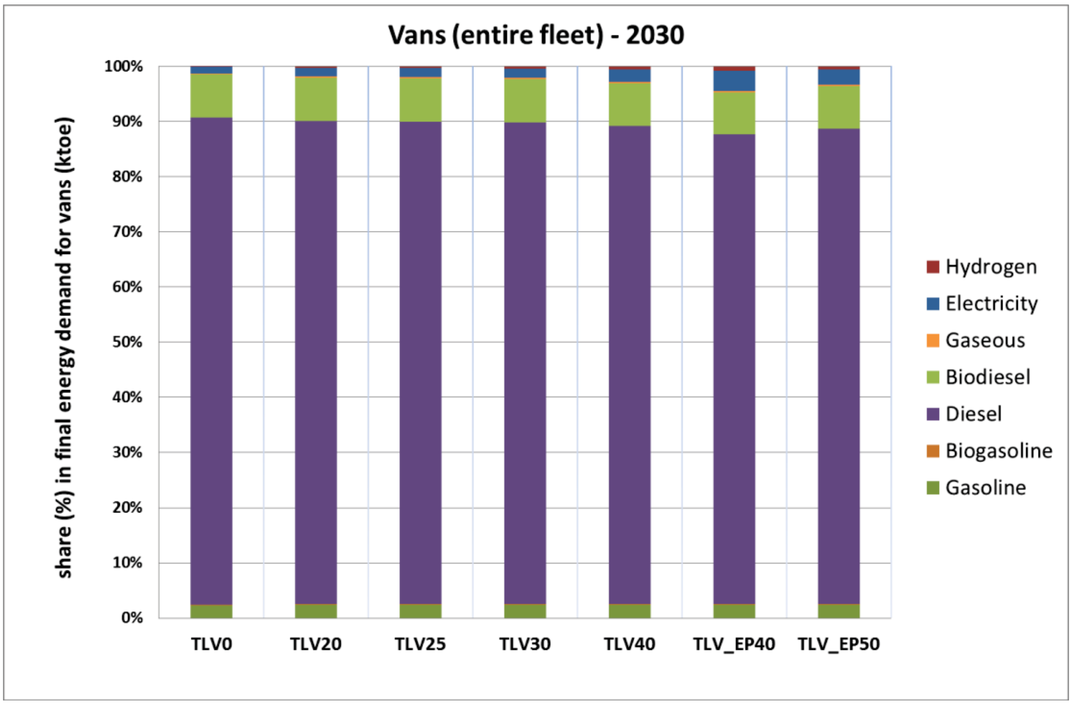
The EU-wide fleet targets for CO_2 also affect the composition of the new van fleet in terms of the powertrains used and hence have an impact on the demand per type of energy source.

Figure 21 shows the share of different fuel types used in the entire van fleet, i.e. not only the newly registered vans, in 2025 and 2030. This indicates that diesel remains by far the main fuel used for vans in 2025 and 2030, there is quite a limited shift away from fossil to alternative fuels, in particular electricity. The shift is slightly more significant in 2030 and for more stringent CO_2 targets. For the other fuel types gasoline, bio-gasoline, biodiesel, and gaseous fuels, there are very limited changes amongst the different options considered. It illustrates that because of the limited overall turnover rate of vans even high sales targets will only lead to gradual changes in the demand for different fuels in 2025 and 2030.

The share of cars and vans in the total EU-28 electricity consumption is shown in Table 9 (Section 6.3.2.2.1.4).

Figure 21: Share (%) of different fuel types in the final energy demand for vans (entire fleet) under different TLV options –2025 and 2030





6.3.2.2.3 Macro economic impacts, including employment

6.3.2.2.3.1 Introduction and methodological considerations

The E3ME and GEM-E3 models are used to assess macroeconomic and sectoral economic impacts (see Annex 4 for a detailed description). In particular, these models are used to quantify the impacts of the different CO_2 targets for light-duty vehicles on the wider economy, i.e. GDP, sectoral output and employment.

Table 19 shows the options for the target levels which were considered in the scenarios modelled by E3ME and GEM-E3. The macro-economic impacts of a combination TL25 (combining TLC25 and TLV25) would be very similar to those of the modelled scenario TL30c/25v.

Table 19: Scenarios modelled with E3ME and GEM-E3 for assessing the macro-economic impacts of the TLC and TLV options

E3ME and GEM-E3 scenario	Cars target level option	Vans target level option
Baseline (TL0)	TLC0	TLV0
TL20	TLC20	TLV20
TL30c/25v	TLC30	TLV25
TL40	TLC40	TLV40

All the modelled scenarios estimate changes due to the new CO_2 target levels in order to isolate the macroeconomic effects of this specific policy. In all scenarios, government revenue neutrality is imposed. The implementation of the new CO_2 targets reduces petrol and diesel consumption, which are commodities upon which taxes are levied in all Member States. This is compensated, in all scenarios, by a proportional increase of VAT rates. As an example, in the scenario TLC30c/25v modelled through E3ME, it is projected that fuel duty revenues in the EU28 decrease by around 6,000 million euros in 2030, corresponding to a 5% decrease with respect to the baseline. The fuel duty revenue loss represents around 0.04% of the EU28 GDP. To ensure revenue neutrality, VAT total revenues increase by around 0.3% in 2030.

6.3.2.2.3.2 GDP impacts

E3ME modelling results for GDP

Table 20 shows the projected GDP impact for the EU-28 for the three scenarios compared against the baseline. The results shown are based on the assumption that the battery cells used in electric vehicles are imported from third countries. Further analysis regarding the impacts of the production of battery cells in the EU is presented in Section 6.5.4.

Table 20: GDP impacts in the baseline (million euros) and percentage change from the baseline under the policy scenarios – battery cells imported (E3ME results)

Scenario	2025	2030	2035	2040
Baseline (M€)	16,018,660	17,087,725	18,381,955	19,892,587
TL20	0.00%	0.01%	0.02%	0.03%
TL30c/25v	0.00%	0.02%	0.03%	0.05%

TL40	-0.01%	0.02%	0.05%	0.07%

The results show compared to the baseline a very small positive impact of the three policy scenarios on EU-28 GDP from 2030 onwards. It is projected that with tighter CO_2 targets for LDV slightly increased consumer expenditure as well as increased infrastructure investment would be triggered. Together with a reduction in imports of petroleum products, this would result in an overall small positive impact on GDP.

At the sectoral level, there would be an expansion of the automotive supply chain, with a production increase in sectors such as rubber and plastics, metals and electrical and machinery equipment. This reflects the impact of increased demand for batteries and electric motors.

The automotive sector itself would see a decrease in value added due to the decreasing use of combustion engines in cars. Similarly, the power and hydrogen supply sectors would increase production reflecting increased demand for electricity and hydrogen to power EVs, while the petroleum refining sector would see losses. With higher target levels, these effects would become slightly more pronounced.

Table 21 shows the main impacts on the output within the most affected sectors in 2030 for the different scenarios. The other sectors overall see smaller but positive impacts due to the projected increased overall economic output.

Table 21: Impacts on the output within the most affected sectors in 2030 (million euros) and percentage change from the baseline – battery cells imported (E3ME results)

Sector	Baseline (M€)	TL20	TL30c/25v	TL40
Petroleum refining	410,422	-0.9%	-1.1%	-1.7%
Automotive	1,076,972	0.0%	-0.1%	-0.5%
Rubber and plastics	317,932	0.3%	0.4%	0.4%
Metals	1,044,999	0.3%	0.3%	0.4%
Electrical equipment	1,091,185	0.7%	0.9%	1.7%
Electricity, gas, water, etc	1,124,221	0.2%	0.3%	0.5%

GEM-E3 modelling results for GDP

GEM-E3 is a general equilibrium model. It therefore assumes that the economy is in perfect equilibrium, with no spare capacity that, if used, would boost economic output. Capital resources are fully employed in the economy. This has consequences when introducing policy changes, with GEM-E3 typically seeing crowding out effects of investments. A policy intervention to increase investments in a particular sector, for instance road transport therefore limits capital availability for other sectors.

The model was run using two variants: a "self-financing" variant where businesses and households finance their investments in more efficient vehicles by spending less on other items; a "loan-based" variant where businesses and households receive a 10-year loan (2% real interest rate) that is fully paid back within this period to purchase more efficient vehicles.

Table 22 shows the GDP impact of scenario TL30c/25v, for the two financing schemes, in terms of percentage changes with respect to the baseline. In the self-financing variant, the crowding out effect is dominant and the impact is marginally negative.

The loan-based variant presents a slightly positive effect that diminishes over time as the investment and expenditure for new advanced vehicles is reduced and loans start to be paid back. In this case, in the short term, the slightly positive impacts are mostly driven by the additional investments. The possibility for firms and households to finance their purchases through loans stimulates demand without crowding out other investments. Over time, as the stock of more efficient vehicles builds up, the impact from fuel savings becomes gradually more important.

Table 22: GDP impacts in the baseline (million euros) and percentage change from the baseline under scenario TL30c/25v comparing the self-financing and loan-based variants – battery cells manufactured in the EU (GEM-E3 results)

	2025	2030	2035	2040
TL0 (Baseline)	15,564,081	16,654,923	17,941,843	19,388,241
TL30c/25v self-financing	-0.014%	-0.014%	-0.024%	-0.040%
TL30c/25v loan-based	0.016%	0.053%	0.066%	0.041%

The GDP impacts for the other scenarios assessed are similar. Table 23 presents the GDP impact for the scenarios TL20, TL30c/25v and TL40 in terms of changes with respect to the baseline, in the loan-based variant. The positive impact tends to be slightly higher for the scenarios with tighter CO_2 target, where higher expenditures for more efficient vehicles, financed by loans, increase GDP.

Table 23: GDP impacts in the baseline (million euros) and percentage change from the baseline under the policy scenarios - loan-based variant – battery cells manufactured in the EU (GEM-E3 results)

	2025	2030	2035	2040
TL0 (Baseline)	15,564,081	16,654,923	17,941,843	19,388,241
TL20 loan-based	0.015%	0.045%	0.044%	0.021%
TL30c/25v loan-based	0.016%	0.053%	0.066%	0.041%
TL40 loan-based	0.021%	0.110%	0.169%	0.108%

Vehicles manufacturing, electrical equipment manufacturing[164], fossil fuels production and power generation are the most impacted sectors. Table 24 shows the sectoral results in percentage changes with respect to the baseline. Starting from quite a low baseline, the increases in manufacturing of electric vehicles are expected to be quite significant ranging between 40-50% at 20%, 50-60% at 30%, and 90-165% at the 40% CO_2 target levels. Still, as already seen earlier in the change of the composition of the overall fleet, the impact on the manufacturing of conventional vehicles would be limited at 20 % and 30% CO_2 target levels. Even at 40% CO_2 target, production would still be reduced by less than 6 % in 2030. Similarly, fossil fuel production is only slightly affected up to 2040, while at the same time production of electrical equipment and electricity would increase slightly.

[164] In the present version of GEM-E3 the manufacturing of batteries is not represented as a separate sector but it is assumed to be part of the electrical equipment sector.

Table 24: EU-28 production by sector in the baseline (million euros) and percentage change from the baseline under the policy scenarios (GEM-E3 results)

Sectors	Scenario	2025	2030	2040
Manufacturing of electric vehicles	TL0 (Baseline)	24,424	52,785	88,590
	TL20	47.2%	40.9%	49.6%
	TL30c/25v	49.8%	57.4%	53.7%
	TL40	93.1%	165.9%	94.2%
Manufacturing of conventional vehicles	TL0 (Baseline)	845,066	893,707	1,025,884
	TL20	-0.8%	-1.3%	-2.4%
	TL30c/25v	-0.9%	-1.9%	-2.4%
	TL40	-1.6%	-5.6%	-4.2%
Electrical equipment (including batteries)	TL0 (Baseline)	923,368	950,849	1,019,439
	TL20	0.3%	0.4%	0.7%
	TL30c/25v	0.3%	0.6%	0.7%
	TL40	0.6%	1.8%	1.3%
Fossil Fuels	TL0 (Baseline)	589,878	579,307	582,956
	TL20	-0.2%	-0.4%	-0.8%
	TL30c/25v	-0.2%	-0.5%	-1.0%
	TL40	-0.3%	-1.3%	-1.9%
Electricity	TL0 (Baseline)	1,054,960	1,134,433	1,287,253
	TL20	0.2%	0.4%	1.1%
	TL30c/25v	0.2%	0.5%	1.2%
	TL40	0.3%	1.2%	2.3%
Other Sectors	TL0 (Baseline)	25,608,768	27,055,166	30,723,227
	TL20	0.02%	0.03%	0.00%
	TL30c/25v	0.02%	0.04%	0.01%
	TL40	0.02%	0.05%	0.02%

6.3.2.2.3.3 Employment

E3ME modelling results on employment

As shown in Table 25, with stricter CO_2 target levels resulting in an increase in economic output, there is also an increase of the number of jobs across the EU-28 compared to the baseline, be it overall in limited numbers. The number of additional jobs also increases over time. The main drivers behind the GDP impacts also explain the employment impacts. The first table shows the results under the assumption that battery cells used in electric vehicles are imported in the EU from third countries, while for the second table it is assumed Europe develops its own battery sector. As can be seen, the impacts are more positive

Table 25: Total employment impacts (E3ME) in terms of number of jobs in (000s) and changes to the baseline (000s jobs)

Battery cells imported from third countries	2030	2035	2040
Baseline	230,207	225,871	223,148
TL20	20	71	122
TL30c/25v	20	103	149
TL40	86	189	213

Battery cells manufactured in the EU	2030	2035	2040
Baseline	230,233	225,905	223,181
TL20	31	111	122
TL30c/25v	71	133	239
TL40	88	197	334

In the different options assessed, the market uptake of battery and plugin hybrid electric vehicles increases with respect to the baseline, but the conventional powertrains remains the large majority of the fleet, as shown in Table 6. While manufacturing battery electric vehicles has a lower labour intensity than conventional vehicles, the labour intensity of manufacturing of plug-in hybrid electric vehicles is higher. As a consequence of the changes in the powertrain shares in the fleet, the impact on employment remains positive.

At sectoral level, similar conclusions as for the impacts on the output can be drawn. The overall impacts are small. Positive impacts are mainly seen in the sectors supplying to the automotive sector as well as in the power sector. Other sectors enjoy some positive second order effects, e.g. as a result of overall increased consumer expenditure. As shown in Table 26, for these sectors combined, the TL30c/25v scenario results in 22,000 additional jobs in 2030, while 4,000 jobs are lost in the petroleum refining and the automotive sectors.

Table 26: Employment impacts, broken down by sector - 2030 (E3ME model)

	Baseline	TL20	TL30c/25v	TL40	TL20	TL30c/25v	TL40
	Number of jobs (000s)	Number of jobs (000s) change from baseline			% change from baseline		
Petroleum refining	151	0	-1	-1	-0.2%	-0.3%	-0.5%
Automotive	2,454	0	-3	-12	0.0%	-0.1%	-0.5%
Rubber and plastics	1,776	5	5	7	0.3%	0.3%	0.4%
Metals	4,288	5	5	5	0.1%	0.1%	0.1%
Electrical equipment	2,451	5	7	12	0.2%	0.3%	0.5%
Electricity, gas, water, etc	2,852	2	2	5	0.1%	0.1%	0.2%
Other sectors	200,427	3	3	69	0.0%	0.0%	0.0%
Total	***230,209***	***20***	***18***	***86***	***0.01%***	***0.01%***	***0.04%***

GEM-E3 modelling results on employment

Total employment increases slightly with respect to the baseline in the policy scenarios. Higher levels of ambition for the CO_2 target would lead to a higher increase in the number of jobs. The table below shows economy-wide results, based on the assumption that the batteries used in electric vehicles would be manufactured in the EU.

Table 27: Employment impacts under the Baseline (000s jobs) and policy scenarios (% change from Baseline) under the loan based financing variant – battery cells manufactured in the EU (GEM-E3)

Scenario	2025	2030	2035	2040
TL0 (Baseline)	218,609	216,367	214,265	212,852
TL20 loan-based	0.01%	0.01%	0.02%	0.01%
TL30c/25v loan-based	0.01%	0.02%	0.02%	0.02%
TL40 loan-based	0.01%	0.04%	0.05%	0.04%

In the case where batteries are manufactured exclusively outside the EU, it was estimated for the TL30c/25v scenario that the number of jobs would slightly decrease by around 0.016% with respect to the baseline. Even if this scenario remains unlikely, it confirms the importance of additional measures to ensure battery production within the EU.

The sectoral breakdown of the employment impact, in Table 28, shows that the new jobs are mainly created in three sectors: advanced vehicles manufacturing, batteries production, and electrical equipment.

Table 28: Employment impacts, broken down by sector under the Baseline (000s jobs) and policy scenarios (% change from Baseline) under the loan based financing variant – battery cells manufactured in the EU (GEM-E3 model)

Sectors	Scenario	2025	2030	2040
Manufacturing of electric vehicles	Baseline	75	147	206
	TL20	47.1%	38.3%	48.6%
	TL30c/25v	49.8%	55.6%	51.1%
	TL40	93.8%	159.8%	85.6%
Manufacturing of conventional vehicles	Baseline	3,340	3,174	2,998
	TL20	-0.9%	-1.4%	-2.5%
	TL30c/25v	-0.9%	-2.0%	-2.5%
	TL40	-1.6%	-5.8%	-4.3%
Electrical equipment goods (including batteries)	Baseline	4,002	3,740	3,337
	TL20	0.3%	0.4%	0.7%
	TL30c/25v	0.3%	0.6%	0.7%
	TL40	0.5%	1.7%	1.2%
Fossil Fuels	Baseline	697	632	519
	TL20	-0.1%	-0.1%	-0.2%

	TL30c/25v	-0.1%	-0.2%	-0.2%
	TL40	-0.1%	-0.5%	-0.6%
Electricity	Baseline	2,351	2,528	2,660
	TL20	0.2%	0.4%	1.1%
	TL30c/25v	0.2%	0.5%	1.2%
	TL40	0.3%	1.2%	2.3%
Other Sectors	Baseline	208,144	206,146	203,132
	TL20	0.00%	0.00%	-0.02%
	TL30c/25v	0.00%	-0.01%	-0.02%
	TL40	-0.01%	-0.03%	-0.03%

Other studies

External studies assessing the possible impacts of an accelerated uptake of low- and zero-emission vehicles conclude that this would lead to an increase in overall employment. A series of macroeconomic studies – both for the EU-28 as a whole[165] and for some individual Member States[166] – show positive impacts on the wider economy, including growth in GDP and employment.

Positive impacts are also confirmed at the level of car manufacturing even for scenarios with significantly higher shares of electrified powertrains as high as 100%.

However, the overall employment impacts will be influenced by the actual technology mix and how other transformative processes such as digitalisation or new business models, e.g. car sharing, will affect the automotive sector.

A literature review[167] of recent studies on employment impacts of a higher share of electrified powertrains confirms that the majority of studies conclude with positive impacts on employment. However, the review points out that the positive impacts on employment rely *inter alia* on the assumption that the EU would retain its technological leadership also in the area of electrified powertrains.

A more detailed summary of the external studies on employment and qualifications is presented in Annex 7.

Broader impacts on employment and qualification of workers

A higher share of electronic components will require different and additional skills compared to the skills needed for the development, manufacturing and maintaining of conventional powertrains ('reskilling'). At the components level, the assembly of electric

[165] Fuelling Europe’s Future, https://www.camecon.com/how/our-work/fuelling-europes-future/

[166] Fuelling France / En route pour un transport durable, 2015, https://www.camecon.com/how/our-work/en-route-pour-un-transport-durable/; Fuelling Britain's Future (FBF), 2015, https://www.camecon.com/how/our-work/fuelling-britains-future/; Low Carbon Mobility in Germany: Challenges and Economic Opportunities, 2017, https://europeanclimate.org/low-carbon-mobility-in-germany-challenges-and-economic-opportunities./

[167] FTI Consulting (2017): The impact of Electrically Chargeable Vehicles on the EU economy, A literature review and assessment. Study prepared for ACEA: http://www.fticonsulting.com/~/media/Files/emea--files/insights/reports/impact-electrically-chargeable-vehicles-eu-economy.pdf

engines is technically more complex compared to a conventional engine combined with a more important role for electronics and digitalisation. This will require better qualified people ('upskilling'). The consequences for employment and qualification will be different for each actor in the automotive supply chain. It is expected that some parts of the value chain will shift from manufacturers to other parts of the supply chain and vice versa.

A stakeholder meeting organised during the preparation of this impact assessment[168] was dedicated to better understand the potential social impacts of the transition to electrified powertrains. It brought together key results of recent studies as well as stakeholder views on how the uptake of low- and zero-emission vehicles may affect employment and skills (see Annex 2). It showed positive effects on total employment in the automotive sector and for the economy as a whole by 2030 also when penetration rates as high as 40% BEV or FCEV and 30% PHEV were assumed.[169] However, the magnitude of the impacts on employment in particular in car manufacturing will depend on the scale and speed of other on-going transformative processes in the automotive industry, e.g. digitalisation, new business models such as car sharing will affect the sector.[170]

The adaptive capacity to cope with these changes varies across the automotive value chain both for companies and employees. SMEs that are highly specialised in certain elements of conventional powertrains may need more time to identify and develop new business opportunities. Unqualified or low qualified workers may have more difficulties in acquiring the new skills and qualifications needed. Similarly, regions with industry clusters built around conventional powertrains or with a strong refining industry may be more negatively affected.

However, the challenges and opportunities in particular for SMEs will be influenced by the speed of the transition to low- and zero-emission vehicles. While the policy options considered will require different transition speeds, all of them would only lead to a gradual transition and not disruptive technological change. In all scenarios by 2030, conventional powertrains, either as stand-alone or as hybrid technologies, will still be fitted in the majority of new vehicles and therefore continue to play a key role. This will provide also highly specialised SMEs and their employees with flexibility to adjust to new technologies and enter new markets while still benefitting from their strengths in incumbent technologies.

Independently from the uptake of alternative powertrains, the automotive industry – as all other sectors – will be faced with fundamental changes in labour markets. Demographic changes will significantly reduce the labour force potential until 2030 and

---

[168] Stakeholder meeting "Revision of the Regulations on CO_2 emissions from light-duty vehicles (post-2020) – Impact on jobs and skills in the automotive sector", Brussels, 26 June 2017.

[169] Fraunhofer IAO (2012): Elektromobilität und Beschäftigung – Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB), http://www.muse.iao.fraunhofer.de/content/dam/iao/muse/de/documents/AbgeschlosseneProjekte/elab-abschlussbericht.pdf . The study does not consider how much the workforce is affected along the value chain, e.g. component suppliers, not does it look at labour structures. These issues are assessed in a follow-up study "ELAB2". Results were not available yet at the time of writing.

[170] Deloitte: The Future of the Automotive Value Chain – 2025 and beyond, https://www2.deloitte.com/de/de/pages/consumer-industrial-products/articles/automotiv-value-chain-2025.html

beyond. According to the 2015 Ageing Report[171], total labour supply in the EU28 is projected to almost stabilise between 2013 and 2023, while it is expected to decline by 8.2% between 2023 and 2060, equivalent to roughly 19 million people. As a result, the automotive sector may be faced with a shortage of qualified employees. Against these labour market issues in the EU it was suggested that less labour intensive technologies such as BEVs could indeed improve the EU's competitiveness[172].

A number of measures have been identified on how to allow the workforce to adapt to the new qualification needs and to make the transition socially fair[173]. Possible actions include industrial collaboration, building new value chains, creating social dialogue, supporting the employability and retraining of workers / lifelong learning, stimulating entrepreneurship and creating new job opportunities in the circular economy.

For this reason, as part of the High Level Group for the automotive industry GEAR 2030[174] a "Human Capital" Project Team was established to "identify the impact on employment in the EU, prepare approaches for mitigating possible negative consequences and develop a strategy for ensuring that the necessary skills will be available in 2030" for the EU automotive industry. The Project Team assessed the landscape of existing initiatives across the EU, looked at what trends will impact the sector up to 2030. Specifically, it investigated the skills and human capital needs and concluded with specific recommendations on EU and Member State actions on developing digital skills and supporting (re-)qualification programmes.

In addition, the Commission's Blueprint-initiative[175] launched in May 2017 includes the automotive sector as one of the sectors targeted. It offers the possibility for project applications to bring together key stakeholders from the social partners to identify qualification / skills challenges combined with the roll-out of tailored strategies at national/regional level to address these challenges.

6.3.2.3 Social Impacts

A first element considered as regards social impacts is whether and to what extent the EU-wide CO_2 fleet targets affect different population groups differentiated according to income groups.

A study[176] looking at the dynamics of the used car market and the distribution of costs and benefits of the EU legislation on CO_2 emission standards for LDV confirmed that used vehicles are far more important for lower income groups and showed that used vehicles tend to be older among lower income groups.

---

[171] European Commission (2014): The 2015 Ageing Report: Underlying Assumptions and Projection Methodologies, http://ec.europa.eu/economy_finance/publications/european_economy/2014/pdf/ee8_en.pdf

[172] FTI Consulting (2017): The impact of Electrically Chargeable Vehicles on the EU economy, A literature review and assessment. Study prepared for ACEA: http://www.fticonsulting.com/~/media/Files/emea--files/insights/reports/impact-electrically-chargeable-vehicles-eu-economy.pdf

[173] InudstriAll (2017): Structural change in the automotive industry – How to deal with the social consequences? Presentation by Guido Nelissen, Brussels, 26 June 2017.

[174] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8640

[175] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8848

[176] Transport & Mobility Leven (2016) - Data gathering and analysis to improve the understanding of 2nd hand car and LDV markets and implications for the cost effectiveness and social equity of LDV CO2 regulations (report for the European Commission, DG CLIMA)

The study identified a correlation between the fuel efficiency of a vehicle and its purchase price on the used vehicle market. Reduced CO_2 emissions were found to have a positive effect on the value of a passenger car on the second hand market of around 22 EUR per gram CO_2 per km. This means that the lower the CO_2 emissions of a used car, the higher the price an owner can ask for when selling its used car. This price premium is passed on between subsequent car owners and increases with the sequence of owners. There is progressive pricing of fuel efficiency with increasing vehicle age.

Due to the socio-economic properties of the used vehicle market, this in turn causes a redistribution of the benefits of fuel efficiency measures towards the lower income groups and, consequently, towards regions where a larger share of the population belongs to those income groups.

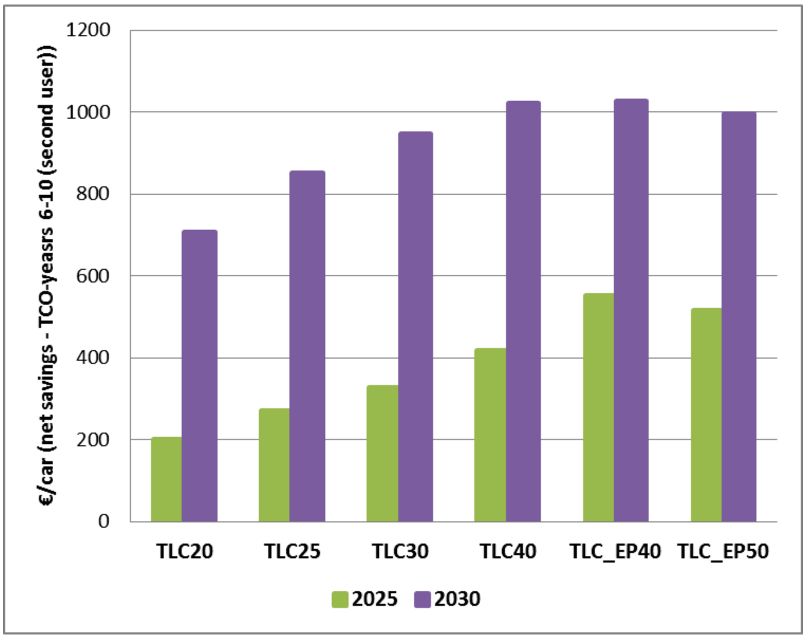
In view of this, the quantitative assessment of the options for the fleet-wide CO_2 targets for new vehicles looked also at the total cost of ownership for the second users. This parameter reflects the difference between a policy scenario and the baseline in the capital costs, O&M costs and fuel cost savings, during the sixth to tenth year of use of a vehicle registered in 2025 or 2030.

As for the TCO for the first user (see Section 6.3.2.2.2.3), taxes are included and a discount rate of 11% for cars or 9.5% for vans is used and the calculation takes account of the residual value of the vehicle (and the technology added) with depreciation

6.3.2.3.1 TCO for second user - passenger cars (TLC)

The results of the analysis of the TCO for the second user are summarised in Figure 22. Compared to the first user, the second user will benefit from higher net savings under all options and in both years. The highest net savings are found under options TLC40 and TLC_EP40.

Figure 22: TCO-second user (years 6-10) (EUR/car) – 2025 and 2030



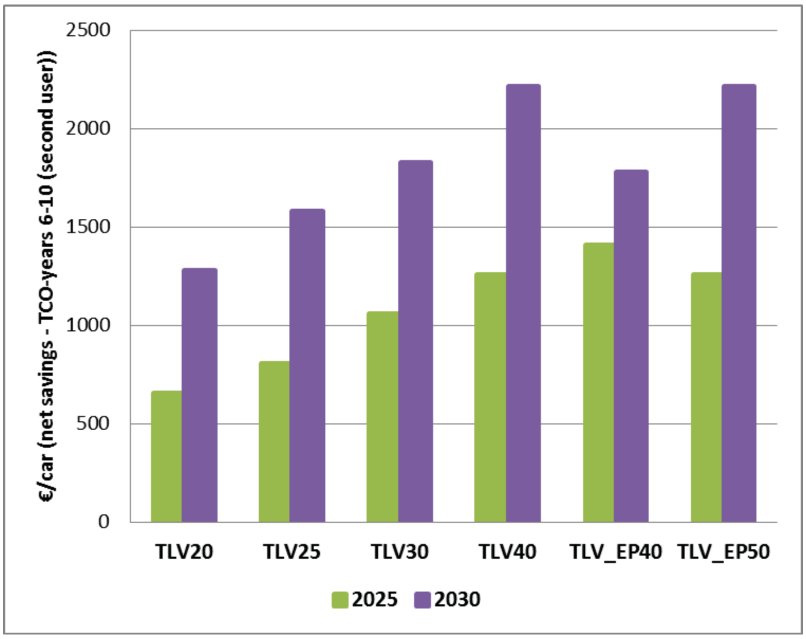
The results of the sensitivity regarding the effect of varying cost assumptions are given in Annex 8.

6.3.2.3.2 TCO for second user - vans (TLV)

Figure 23 shows the net savings from a second end-user perspective for an average new van registered in 2025 and in 2030 under the different options (expressed as the difference with the baseline).

There are net savings for the second user under all options, and the highest savings are achieved under option TLV_EP40 in 2025 and under options TLV40 and TVL_EP50 in 2030. However, the second user savings for vans are lower than for the first user (see Section 6.3.2.2.2).

Figure 23: TCO-second user (years 6-10) (EUR/van) – 2025 and 2030



The results of the sensitivity regarding the effect of varying cost assumptions are given in Annex 8.

6.3.2.4 Environmental impacts

The main environmental impact of EU-wide CO_2 targets for the new LDV fleet concern the tailpipe CO_2 emissions within the sector. The full effect of setting new CO2 targets for newly registered vehicles in the period 2021-2030 will only be realised over time as a larger share of the overall vehicle stock becomes subject to the new targets due to fleet renewal. Therefore, the environmental impacts up to 2040 are shown in this section.

Furthermore, next to 2020, also 2005 is considered as a reference year where this is relevant to put the emission reductions observed in the sector in a broader policy perspective[177].

Well-to-wheel CO_2 emissions have also been assessed[178]. However, due to the interactions with the EU ETS, care must be taken when interpreting these figures in a causal fashion. While indicative of a part of upstream emissions as traditionally defined

[177] 2005 is the reference year for the emission reduction objectives established under the Effort Sharing Decision and the Commission's 2016 Proposal for an Effort Sharing Regulation

[178] In PRIMES-TREMOVE, WTW emissions are defined as upstream emissions, due to fuel and electricity production, on EU territory only. These emissions change as the vehicle mix changes.

in LCAs, they should not be interpreted as the impact on CO_2 emissions of the vehicle standards alone. Furthermore, the assessment looked at possible changes in the embedded CO_2 emissions (related to the manufacturing of the vehicle and its components) triggered by the targets.

A change in fuel consumption or mix will not only affect greenhouse gas emissions, but also those of air pollutants (esp. NO_x and particulate matter). These co-benefits of the policy options have also been quantified and assessed.

6.3.2.4.1 Passenger cars (TLC)

CO_2 emissions (tailpipe)

Under the baseline (TLC 0), tailpipe CO_2 emissions from cars in the EU-28 are reduced by 26% between 2005 (543 Mt) and 2030 (402 Mt). A stronger reduction is observed since 2015, when the first CO_2 targets for new cars took effect and the reduction is slowing down after 2030 as no new targets are set beyond 2021.

Figure 24 shows the evolution of the emissions between 2025 and 2040 under the baseline and the TLC policy options comparing them to the 2005 emissions.

Across the options considered, the additional reductions in 2030 on top of the baseline range from 4 percentage points (TLC20) to 11.4 percentage points (TLC_EP50). In 2040, the range is from 19.1 percentage point (TLC20) to 30.3 percentage points (TLC_EP50).

Figure 24: (Tailpipe) CO_2 emissions of passenger cars in EU-28 - % reduction compared to 2005

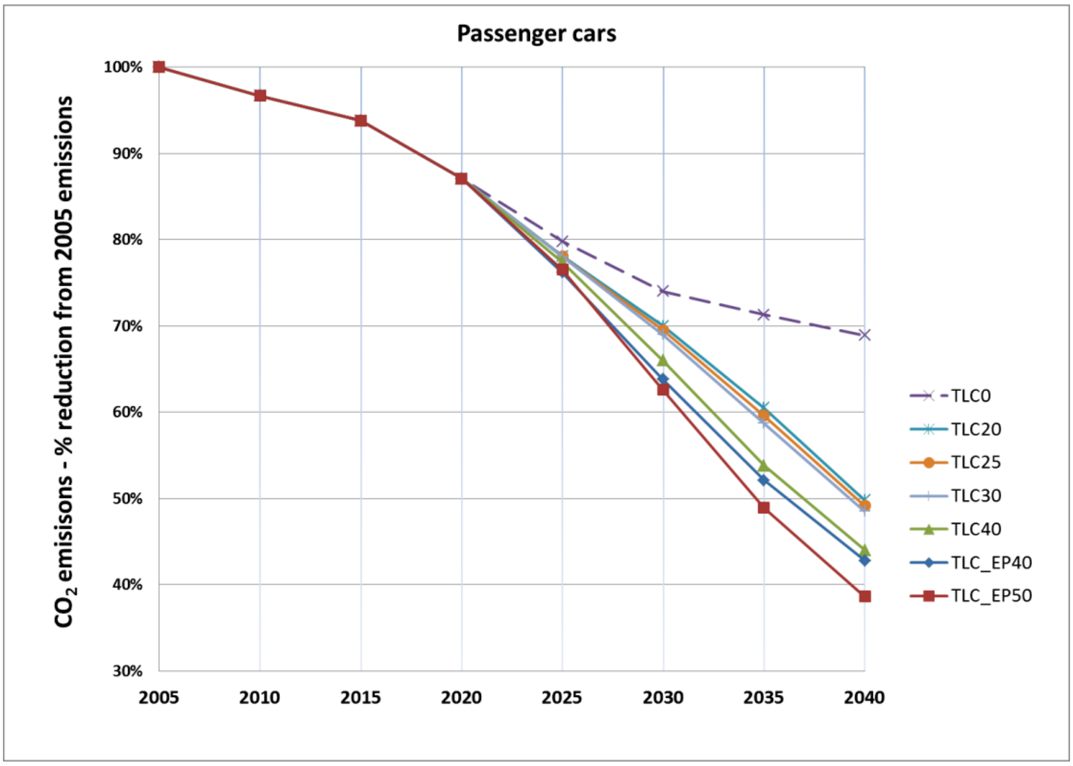
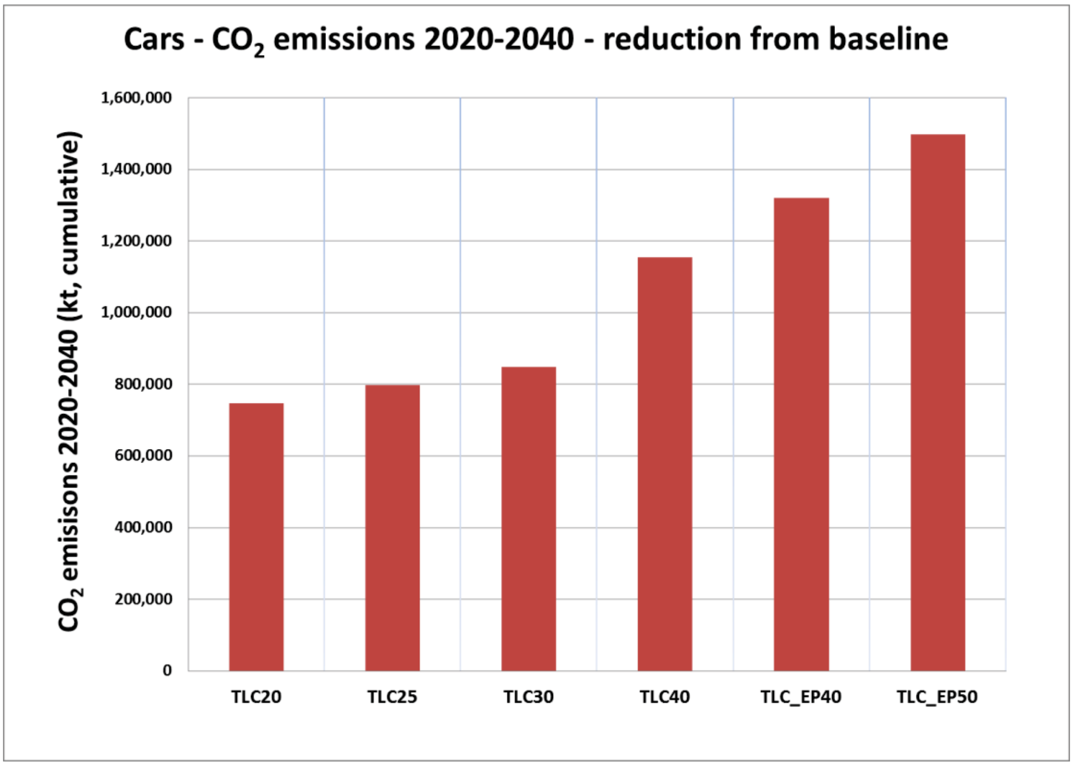


Figure 25 shows the reduction of the cumulative CO_2 emissions over the period 2020-2040 (compared to the baseline) for the different scenarios. For cars, these emission reductions range from about 700 Mt (TLC20) up to nearly 1,500 Mt (TLC_EP50).

Figure 25: Cumulative (tailpipe) 2020-2040 CO_2 emissions of cars for EU-28 – emission reduction from the baseline (kt)



CO_2 emissions (WTW)

When considering the well-to-wheel CO_2 emissions, the trends are very similar, with slightly lower emission reductions. Under the baseline, emissions reduce by 24.8% between 2005 (658 Mt) and 2030 (495 Mt).

Across the options considered, the additional reductions in 2030 on top of the baseline range from 3.6 percentage points (TLC20) to 10.2 percentage points (TLC_EP50). In 2040, the range is from 17.8 percentage points (TLC20) to 28.9 percentage points (TLC_EP50).

Air pollutant emissions

Due to the change in fleet composition under the different policy options concerning the fleet-wide CO_2 target, also the emissions of air pollutants are affected. Under the baseline and TLC options, compared to 2020, emissions of nitrogen oxides and particulate matter (PM2.5) from cars are reduced as shown in the tables below.

Table 29: NO_x emissions of passenger cars in EU-28 - % reduction compared to 2020

NO_x emissions	2025	2030
TLC 0	27%	36%
TLC20	28%	38%
TLC25	28%	39%
TLC30	28%	39%
TLC40	29%	42%

TLC_EP40	29%	43%
TLC_EP50	29%	44%

Table 30: $PM_{2.5}$ emissions of passenger cars in EU-28 - % reduction compared to 2020

$PM_{2.5}$ emissions	**2025**	**2030**
TLC 0	27%	31%
TLC20	22%	33%
TLC25	22%	34%
TLC30	22%	35%
TLC40	22%	42%
TLC_EP40	22%	39%
TLC_EP50	22%	41%

6.3.2.4.2 Vans (TLV)

CO_2 emissions (tailpipe)

Under the baseline (TLV 0), tailpipe CO_2 emissions from vans in the EU-28 are reduced by 17.4% between 2005 (113 Mt) and 2030 (94 Mt). The reduction is slowing down after 2030 as no new van targets are set beyond 2020.

Figure 26 shows the evolution of the emissions between 2025 and 2040 under the baseline and the TLV policy options compared to 2005. Across the options considered, the additional reductions in 2030 on top of the baseline range from 4.8 percentage points (TLV20) to 14.1 percentage points (TLV_EP50). In 2040, the range is from 25.6 percentage points (TLV20) to 38.0 percentage points (TLV_EP50).

Figure 26: (Tailpipe) CO_2 emissions of vans in EU-28 - % reduction compared to 2005

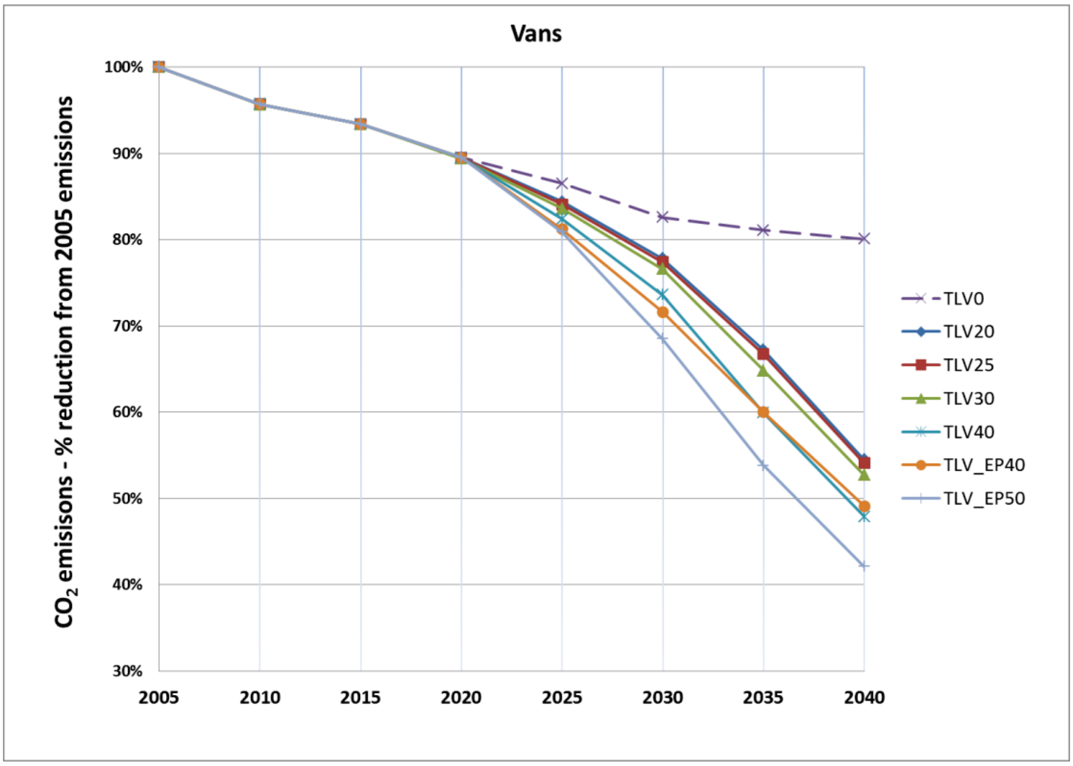
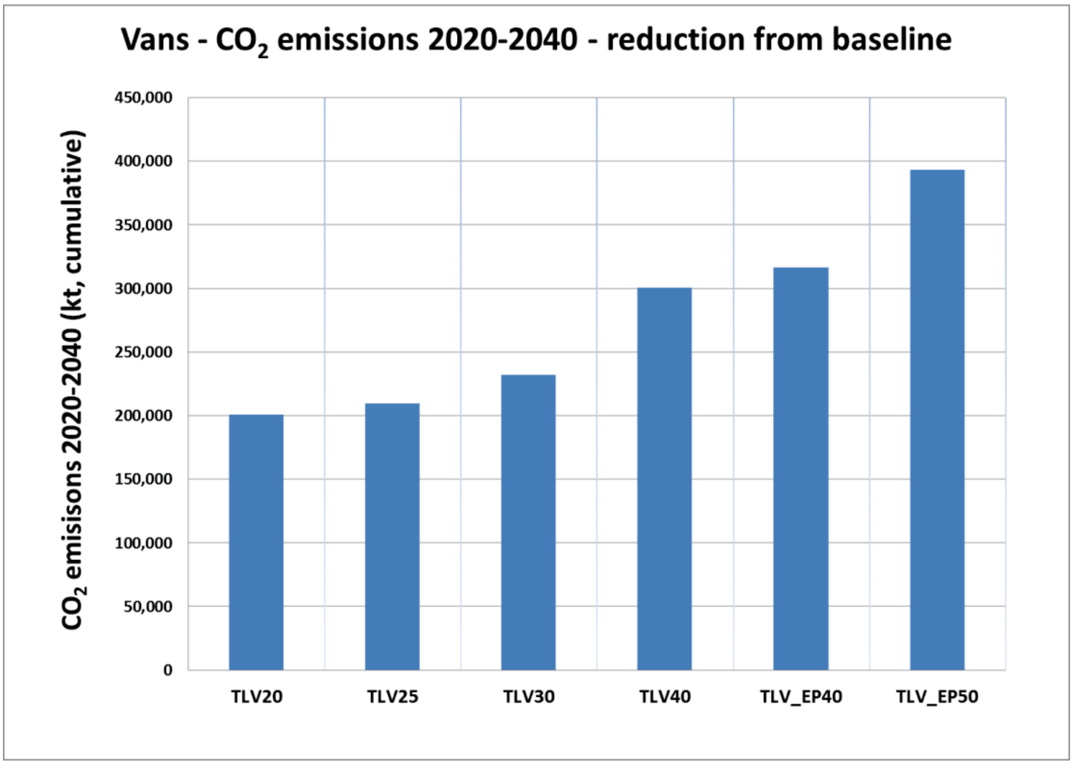


Figure 27 shows the reduction of the cumulative CO_2 emissions over the period 2020-2040 (compared to the baseline) for the different scenarios. For vans, these emission reductions range from about 200 Mt (TLV20) up to nearly 400 Mt (TLV_EP50).

Figure 27: Cumulative (tailpipe) 2020-2040 CO_2 emissions of vans for EU-28 – emission reduction from the baseline (kt)



CO_2 emissions (WTW)

When considering the well-to-wheel CO_2 emissions, the trends are very similar, with slightly lower emission reductions. Under the baseline, emissions reduce by 16% between 2005 (137 Mt) and 2030 (114 Mt).

Across the options considered, the additional reductions in 2030 on top of the baseline range from 4.4 percentage points (TLV20) to 12.3 percentage points (TLV_EP50). In 2040, the range is from 23.2 percentage points (TLV20) to 33.8 percentage points (TLV_EP50).

Air pollutant emissions

Due to the change in fleet composition under the different policy options concerning the fleet-wide CO_2 target, also the emissions of air pollutants are affected. Under the baseline and TLV options, compared to 2020, emissions of nitrogen oxides and particulate matter (PM2.5) from vans are reduced as shown in the tables below.

Table 31: NO_x emissions of vans in EU-28 - % reduction compared to 2020

NO_x emissions	**2025**	**2030**
TLV 0	22%	31%
TLV20	23%	33%
TLV25	23%	33%
TLV40	24%	36%
TLV_EP40	25%	37%
TLV_EP50	25%	41%

Table 32: $PM_{2.5}$ emissions of vans in EU-28 - % reduction compared to 2020

***$PM_{2.5}$* emissions**	**2025**	**2030**
TLV 0	19%	32%
TLV20	20%	33%
TLV25	20%	33%
TLV40	21%	36%
TLV_EP40	22%	38%
TLV_EP50	22%	41%

6.3.2.4.3 Contribution to the ESR targets

As already mentioned in Section 6.1, CO_2 emissions from road transport contribute significantly to the emissions from the sectors not covered under the EU ETS. While the EU is on track to meet its 2020 target for these sectors (i.e. 10% reduction by 2020 with respect to 2005) further efforts are necessary to meet the 30% reduction target by 2030. Maintaining the current CO_2 emission standards for cars and vans would not be sufficient for meeting the EU's 2030 target under the Effort Sharing Regulation, as confirmed by the EU Reference Scenario 2016[179].

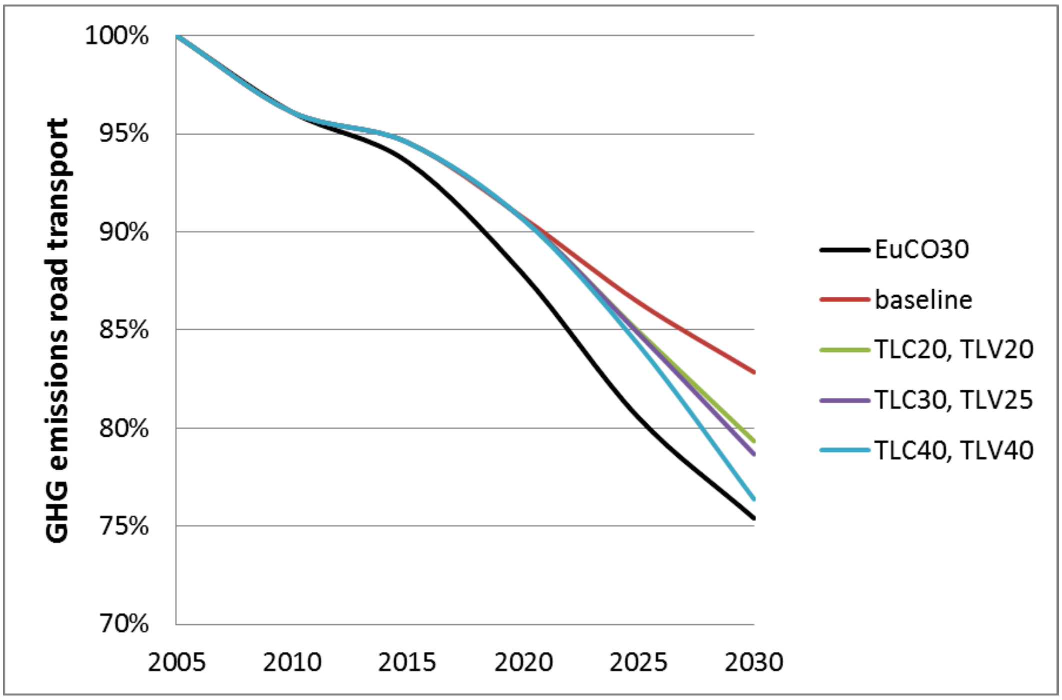
[179] https://ec.europa.eu/energy/en/data-analysis/energy-modelling

The analytical work underpinning the Effort Sharing Regulation and the Energy Efficiency Directive proposals built on the so-called *EUCO30* scenario, under which all 2030 climate and energy targets are met through the implementation of additional policies to the ones assumed under the EU Reference scenario 2016. For the road transport sector, these additional policies included more ambitious CO_2 emission standards for new cars and vans.

Under the *EUCO30* scenario, emissions from road transport are projected to reduce by 25% in 2030 with respect to 2005. Figure **28** depicts projected GHG emissions in the road transport sector for the *EUCO30* scenario and for several of the options considered in this Impact Assessment regarding the EU-wide fleet CO_2 targets for cars (TLC) and for vans (TLV).

It shows a significant difference between the emission reduction in road transport in the *EUCO30* scenario and in the baseline used for this Impact assessment. When setting stricter CO_2 targets for new cars and vans for the period after 2020/2021, this difference gets significantly smaller. However, the options assessed do not close the gap completely, so that further measures to reduce GHG emissions in the road transport sector remain relevant, including for example EU policies setting CO_2 emissions performance standards for trucks.

Figure 28**: Evolution of GHG emissions between 2005 (100%) and 2030 under the *EUCO30* scenario and under the baseline and different policy options for the CO_2 target levels for new cars and vans considered in this impact assessment**



An analysis has also been carried out to assess the contribution of the new CO_2 standards for cars and vans to the Member States targets set in the Effort Sharing Regulation (ESR)[180], which are determined on the basis of the relative GDP per capita.

The analysis is performed by grouping Member States in two groups depending on their 2030 ESR targets. The first group consists of Member States with an ESR reduction target below 20% and the second group are Member States with a target between -20%

[180] COM(2016) 482 final

and -40%. For each group, the weighted average[181] of the 2030 ESR emissions reduction targets was calculated for the purpose of this analysis. Table 33 compares these values with the weighted average[182] of the emissions reductions for light-duty vehicles between 2005 and 2030 under two different options for the EU-wide fleet CO_2 standards[183].

This shows that the new targets will result in more CO_2 emission reductions in Member States with more ambitious reduction targets under the ESR. This general trend can be explained by lower income Member States having higher GDP growth and hence faster transport activity growth. These countries have also a larger second hand market.

Table 33: Comparison of the average of the emission reductions required under the Effort Sharing Regulation (ESR) and emission reductions for light-duty vehicles under different policy options

Member State groups	Weighted average of the ESR emission reduction targets	CO_2 reductions from light-duty vehicles	
		TLC30 / TLV25	TLC30 / TLV40
ESR target < 20%	9%	9%	10%
ESR target ≥ 20%	35%	33%	34%

An additional comparison was performed with the "*EUCO30*" scenario to assess whether the options considered for the automotive sector in this impact assessment are coherent with the broader 2030 energy and climate policy framework. Table 34 shows the emissions from the ESR sectors under the *EUCO30* scenario and in a scenario TLC30c/25v+ where the EU-wide fleet CO_2 targets for new cars and vans are set as in options TLC30 and TLV25 (referred to as TL30c/25v), while assuming also other transport related policies (as in *EUCO30*)[184].

Table 34: Comparison of CO_2 emissions under the *EUCO30* scenario and the TL30c25v+ scenario

	2005	**2030**	
		EUCO30	TL30c/25v+
ESR emissions [Mt CO_2]	2,848	1,985	1,999
% change from 2005		-30.3%	-29.8%

In *EUCO30*, ESR emissions fall by 30.3% in 2030 compared to 2005 levels, which is in line with the 30% target. In the TL30c/25v+ scenario, the reduction is 29.8%. From this assessment, it could be concluded that the new policy scenarios and *EUCO30* are consistent in the GHG savings they deliver in the non-ETS sectors. This assessment also confirms that any remaining gap identified for transport emissions is expected to be

[181] Weighted average, according to the 2005 emissions for the non-ETS sectors under the Effort Sharing Decision

[182] Weighted average, according to the 2005 emissions for light-duty vehicles

[183] The table illustrates that the results are not significantly impacted by the target levels, so similar conclusions would apply for other target level combinations.

[184] These policies concern eco-driving, Cooperative Intelligent Transport Systems (C-ITS), internalisation of transport externalities, road infrastructure charges for Heavy Goods Vehicles, and the targets set in the Commission's 2016 proposal for a revision of the Renewable Energy Directive for the shares of renewable energy sources used in transport..

closed further as additional CO_2 reduction policies are being developed in the transport sector, such as emission standards for heavy-duty vehicles. Additional details on this analysis are presented in Annex 4.

6.3.3 Timing of the targets (TT)

6.3.3.1 Option TT 1: The new fleet-wide targets start to apply in 2030.

Under this option the new targets start to apply in 2030. Even if the 2030 targets can be expected to create some anticipation by manufacturers, the absence of more ambitious CO_2 targets prior to 2030 is very likely to cause a number of CO_2 reducing technologies or LEV/ZEV to be introduced only close to the date of application of the new targets, in particular for those technologies with high manufacturing costs.

Environmental impacts

The expected delayed introduction of fuel-efficient technologies and LEV/ZEV will lead to higher CO_2 and air pollutant emissions in the intermediate period. Furthermore, given the average lifetime of new vehicles, the vehicle stock in 2030 will continue to have higher CO_2 and air pollutant emissions. As a consequence, in this option, the contribution of road transport to the 2030 climate and energy targets risks being more limited.

For example, with EU-wide CO_2 targets as under options TLC30 and TLV25, in the worst case whereby no emission reduction happens by 2025 due to the fact that no new target is set for 2025, the cumulative total CO_2 emissions from light duty vehicles in the period 2020-2030 would be around 81 million tons higher than in a scenario with an interim target in 2025, stimulating an earlier uptake of more efficient vehicles. This is equivalent to around 16% of total annual CO_2 emissions in 2030 in the baseline. Even if some reduction efforts were to be anticipated, this indicates that under this option cumulative CO_2 emissions in the period 2020-2030 would be higher.

Economic impacts

As the new targets start to apply only in 2030, there is a limited incentive for manufacturers to increase and improve their product range of LEV/ZEV at a higher pace than that needed to meet earlier new targets, as is reflected in the currently low market share of these vehicles among new registrations.

This option would provide industry with more lead time to invest and develop new technologies. However, delaying the introduction of more efficient technologies, and LEV/ZEV in particular, could have a negative impact on the technology cost reduction through economies of scale.[185] At the same time, applying the new target in 2030 only may provide a weaker signal to potential investors to invest in alternative powertrains and infrastructure. Given the regulatory developments in other regions in the world, Europe would risk to lose out as lead market (see section 2.1.3). European manufacturers

[185] For instance, based on patent data for combustion engines and alternative technologies for the period 1995-2015, the German automotive industry is among the leading automotive nation in the period 2010-2015. However, this technological potential is not transformed into new products. One reason for industry to rather wait than investing in further development and marketing of these products are the higher costs and the expected economies of scale It is therefore necessary to stimulate the market diffusion of these new technologies. See Falck, O. et al. (2017): "Auswirkungen eines Zulassungsverbots für Personenkraftwagen und leichte Nutzfahrzeuge mit Verbrennungsmotoren" ifo Institut, http://www.cesifo-group.de/portal/page/portal/DocBase_Service/studien/Studie-2017-Falck-etal-Zulassungsverbot-Verbrennungsmotoren.pdf

would not benefit from a first mover advantage with negative effects on their international competitiveness.

Social impacts

Due to the delay in bringing more efficient vehicles on the market, consumers would lose out on fuel cost savings. Moreover, the delay could provide for more time to prepare for the new skills required for the production of low- and zero-emission vehicles ('reskilling' and 'upskilling', see section 6.3.2.2.3.3).

6.3.3.2 Option TT 2: New fleet-wide targets start to apply in 2025, and stricter fleet-wide targets start to apply in 2030.

Environmental impacts

Since targets are set in 2025 and 2030, this option provides for early action well ahead of 2030. Thus, cumulative emission reductions are expected to be higher. *Economic impacts*

Setting CO_2 targets also in 2025 would provide a clear and early signal for the automotive sector to increase the market share of LEV/ZEV in the EU from the early 2020s on. At the same time, it would leave sufficient flexibility to manufacturers to phase in gradually more efficient technologies and hence give sufficient lead time for the automotive supply chain to adapt through a step by step approach. However, this would be less the case where a higher average annual reduction of the target level is foreseen in the earlier period 2021-2025 compared to the later period 2025-2030 such as illustrated by the EP_40 options.

Social impacts

Consumers would benefit from fuel cost savings from the early 2020s on due to an earlier introduction of more efficient vehicles (compared to option TT 1). While the transition to LEV/ZEV would need to commence earlier, there would still be time to prepare for the new skills requirements.

6.3.3.3 Option TT 3: New fleet-wide targets are defined for each of the years until 2030.

Environmental impacts

This option would ensure CO_2 emission reductions follow an annual path, like installations under the emissions trading system, and therefore would provide greater certainty for the expected CO_2 and air pollutant emission reductions to be effectively delivered. It would also ensure timely and continuous market uptake of LEVs/ZEVs.

Economic impacts

Annual targets could be perceived as very prescriptive in imposing a rigid annual emission reduction pathway on manufacturers. Managing year-to-year market fluctuations, for example, due to changes in customer demand would be almost impossible without additional flexibility for compliance between years. It would be challenging for manufacturers to plan the modernisation of models and introduction of new technologies in their fleet against annual emissions targets. In addition, setting annual targets in the first years after 2021 may create a risk of limiting lead time for manufacturers to appropriately plan and implement their strategies for meeting the new targets. Overall, this could make delivery of the targets rather costly.

Social impacts

Consumers would benefit from fuel cost savings as early as possible.

Link with Banking / Borrowing

As explained in section 5.4.4., the timing of the targets affects how banking and borrowing could be implemented. If no annual targets are set (options TT1 and TT2), a target trajectory for banking and borrowing would need to be defined. This would avoid that too many credits are accumulated up to 2025 and/or 2030. There is also the risk that a manufacturer or pool could significantly exceed the target and hence undermine the intended CO_2 emission reductions for that time period.

6.4 Distribution of effort (DOE)

6.4.1.1 Methodology and introduction

In order to assess the impact of using a utility based or other distribution function for defining the CO_2 target of individual manufacturers, the JRC developed an additional model (DIONE). For this, a limited number of manufacturer categories were defined taking into account key common features (see below).

Starting from the segment/powertrain shares resulting from the PRIMES-TREMOVE model, the impacts per manufacturer category were analysed, taking account of their fleet characteristics in terms of utility and share of different powertrains and segments.

For a given CO_2 target in a given year and applying one of the DOE options, the average manufacturing cost increase against the baseline per vehicle is calculated for each manufacturer category.

Manufacturer categorisation

As it is not possible to accurately predict the evolution of the average vehicle mass or footprint for actual manufacturers over time, the results of this assessment are rather presented for a limited number of "stylised" manufacturers, each representative of manufacturers with similar specific characteristics. The criteria used for defining the manufacturer categories are the fleet composition in terms of market segments for small, medium, and large cars and the readiness to increase the uptake of low-emission vehicles. The resulting passenger car and LCV manufacturer categories are presented in the tables below[186].

[186] Small volume manufacturers (with < 10,000 passenger car registrations or <20,000 LCV registrations) and manufacturers below the *de minimis* threshold (<1,000 vehicles registered) are not considered in this quantitative analysis.

Table 35: Categories of passenger car manufacturers considered for the assessment of the DOE options

Category	Predominant segment[187]	Expected LEV uptake level[188]
Manufacturer of smaller cars	Small	Low
Advanced technology average car manufacturer	Medium	Early market leader
Average car manufacturer	Medium	Average/Low
Advanced technology manufacturer of larger cars	Large	Early market leader

Table 36: Categories of LCV manufacturers considered for the assessment of the DOE options

Category	Predominant segment[189]	Expected LEV uptake level
Manufacturer of larger LCVs with EVs	Large	EV model sales
Manufacturer of larger LCVs	Large	No EV sales
Manufacturer of smaller LCVs	Small	Variable

Assessment of the variants to option DOE1 (mass based limit value curve with equal reduction efforts for all manufacturers)

As regards option DOE 1, the quantitative assessment was only possible for the case where the utility parameter is 'mass in running order', as no data is yet available on the WLTP test mass of the different vehicles and manufacturers. Similarly, it was not possible to quantify the effect of using different slopes for different categories of vans (i.e. steeper slope for heavier vans).

Overall, the impacts on the results of shifting to WLTP test mass as the utility parameter can be expected to be limited, as it can be assumed that the average 'mass in running order' and the average 'WLTP test mass' correlate quite closely, and this correlation would not differ between different manufacturers or pools. Thus, shifting from 'mass in running order' to 'WLTP test mass' as the utility parameter would not significantly affect the relative position of individual manufacturers or pools on the limit value curve. Possibly, in the case of cars, larger (heavier) vehicles might have relatively more optional features, which would mean that their "WLTP test mass' would increase more compared to smaller (lighter) cars. If so, under an "equal reduction effort" approach, the limit value curve would tend to become less steep (lower slope), making the targets less strict for lighter cars, while tightening them for heavier cars.

[187] "Small": >75% A/B segment vehicles; "Large": >10% large or >50% upper medium+large vehicles; "Medium": other.

[188] "Early market leader": higher deployment/market share of EVs and/or hybrids; "Low": little/no deployment of EVs and hybrids.

[189] "Small": <50% large LCV or >15% small LCV or car-based sales; "Large" = other

As regards the two-slope approach, which was suggested for vans by industry stakeholders, particular care needs to be taken in designing the limit value curve in such a way that it ensures that the EU-wide fleet average CO_2 target is maintained. While a linear limit value curve means that the EU-wide fleet average CO_2 target corresponds with the sales-weighted average mass of the fleet, this is no longer the case for a two-slope approach. Instead, this will require the CO_2 target of a vehicle with a mass equal to the sales-weighted average mass of the fleet to be stricter than the EU-wide fleet CO_2 target. In other words, the overall impact of the two-slope approach compared to the single-slope approach with the same EU-wide fleet target level, would be that the target is slightly relaxed for both the lightest and the heaviest vehicles, while becoming stricter for the middle category (i.e. vans with a mass close to the fleet-wide average mass). In absolute terms, the overall impacts will depend on the target level, but can generally be expected to be rather limited assuming that the two slopes will not be very different.

6.4.1.1.1 Economic Impacts

6.4.1.1.1.1 Average manufacturing costs

The analysis found that, for a given EU-wide fleet CO_2 target, the average manufacturing costs per vehicle relative to the baseline change only marginally across the different DOE options considered.

This was expected as the utility function is merely intended to distribute the effort across the different manufacturers, while not modifying the overall effectiveness and efficiency of the EU-wide fleet CO_2 target level.

For example, when applying the CO_2 target for passenger cars of option TLC30 (see Section 6.3.2), the increase in total manufacturing costs across the options DOE 0 to DOE 4 ranges from 380 to 399 EUR per vehicle in 2025 and from 1020 to 1051 EUR per vehicle in 2030.

Similarly, for vans, with the fleet-wide CO_2 target of option TLV25, the manufacturing cost increase across the options DOE 0 to DOE 4 only ranges from 354 to 378 EUR per vehicle in 2025 and from 619 to 670 EUR per vehicle in 2030.

In view of these limited economic impacts at the EU-wide fleet level, the further assessment will focus on the impacts on manufacturing costs at manufacturer category level, which in turn will affect the vehicle pricing and competitive position.

6.4.1.1.1.2 Impacts on competition between manufacturers

This analysis has looked at how manufacturing costs of different types of manufacturers may change across the DOE options. In addition, since certain vehicle segments (e.g. smaller budget vehicles) are more price sensitive, and, therefore, the same absolute price increase could cause more significant impacts for them, the analysis also considered the cost increase relative to the average price of the vehicles.

Passenger cars

The two figures below show the main results of the analysis for passenger cars in case of an EU-wide fleet CO_2 target in 2025 and 2030 under option TLC30. Figure 29 shows the cost increase per vehicle (EUR/car), while in Figure 30 these costs are related to the vehicle price (cost increase in % of car price).

While results are presented here in relation to only one EU-wide fleet target level options, it should be added that the trends found for other target level options were very similar (the detailed results for TLC25 are shown in Annex 8). The findings mentioned below can thus be equally applied in relation to all TLC options.

Figure 29: Additional manufacturing costs (EUR/car) for categories of passenger car manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLC30

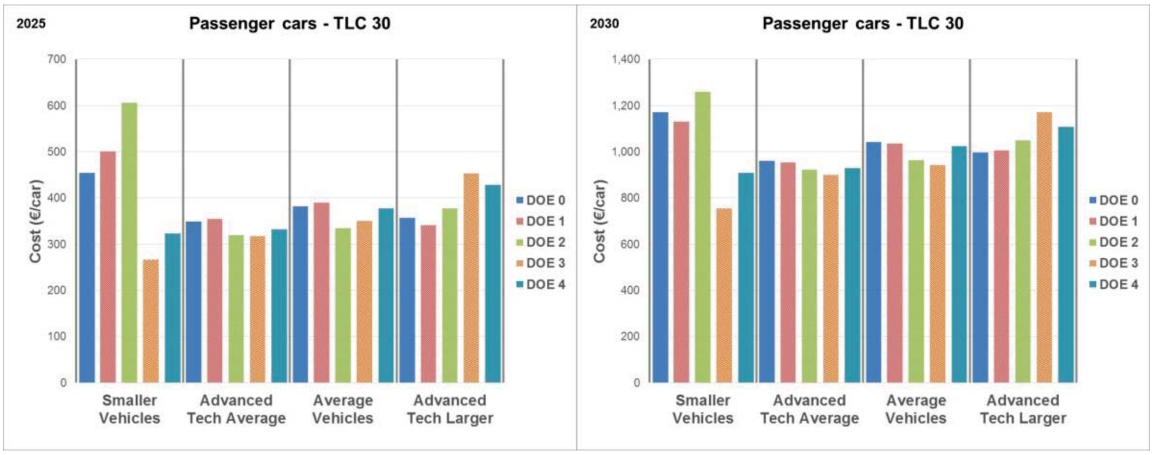
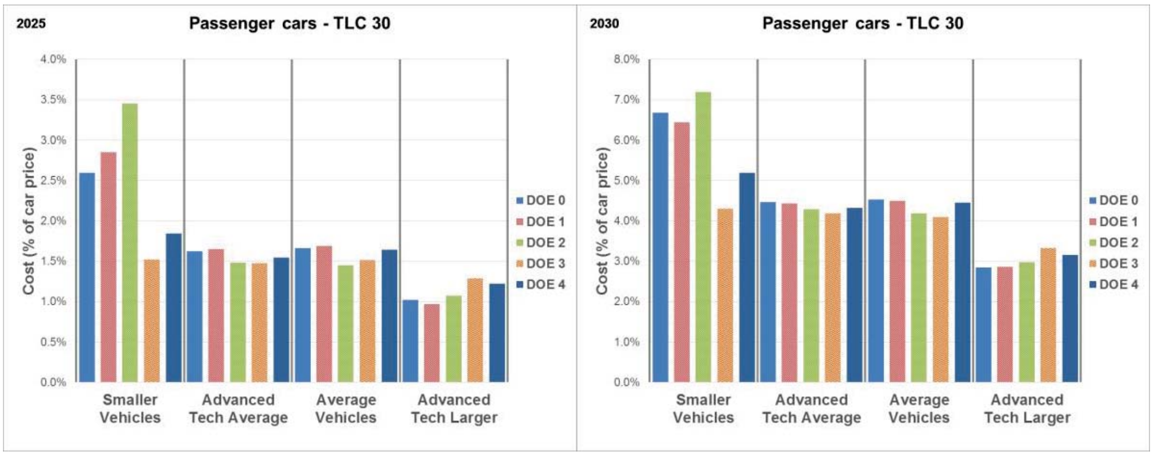


Figure 30: Additional manufacturing costs relative to vehicle price (% of car price) for categories of passenger car manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLC30



Overall, these figures show that for three out of the four categories of car manufacturers the DOE options do not significantly affect the manufacturing costs (not more than 100 EUR/car in 2025 or 200 EUR/car in 2030).

However, manufacturers of smaller cars face far higher additional manufacturing costs under options DOE 0, DOE 1 and, most of all, DOE 2 (footprint based limit value curve) compared to the other options, which are not using a limit value curve. When looking at the relative cost impacts, this effect is even more visible. The opposite effect is seen for the "advanced technology manufacturer of large cars", albeit less outspoken.

Amongst the options considered, the most homogeneous distribution of absolute efforts between manufacturer categories is achieved through a uniform reduction of the target level (DOE 4). However, both this option and option DOE 3 (uniform target) have the drawback of being less flexible in accounting for changes in the utility properties of a manufacturer's fleet as the specific emission targets for individual manufacturers are fixed and do not vary depending on those properties. Therefore, distributing the efforts without taking into account the utility properties may interfere with a manufacturer's strategic choices by limiting future segmentation shifts. This would be particularly challenging for manufacturers producing a less diversified fleet of mainly larger or mainly smaller vehicle models. Finally, for option DOE 4 it also would need to be established how to deal with new entrants.

Vans

The two figures below show the main results for vans with EU-wide fleet CO_2 targets in 2025 and 2030 as under option TLV40. Figure 31 shows the absolute manufacturing cost increase (EUR/van), while in Figure 32 these costs are related to the vehicle price (cost increase in % of van price).

Again, the trends found for other target level options were very similar (the detailed results for TLV25 are shown in Annex 8). The findings mentioned below can thus be equally applied in relation to all TLV options.

Figure 31: Additional manufacturing costs (EUR/van) for categories of van manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLV40

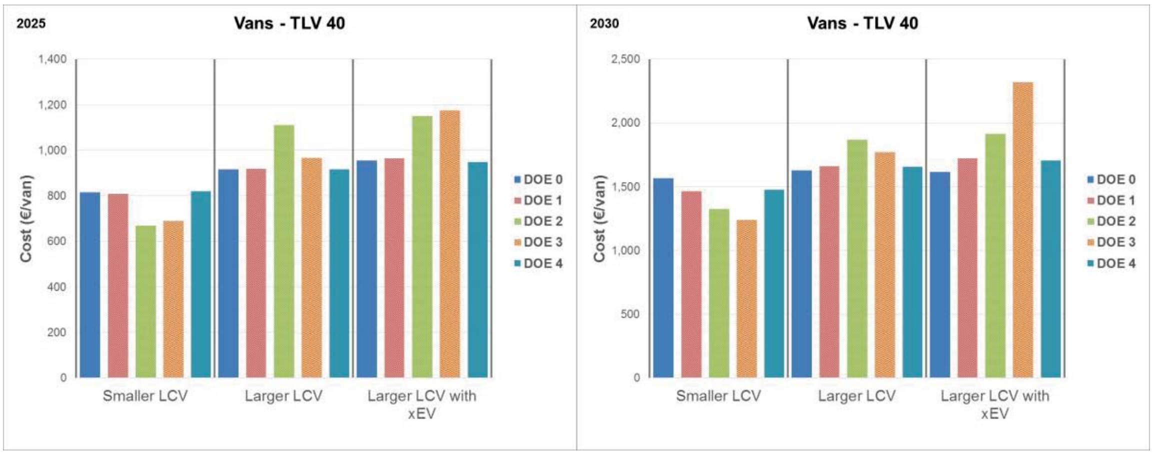
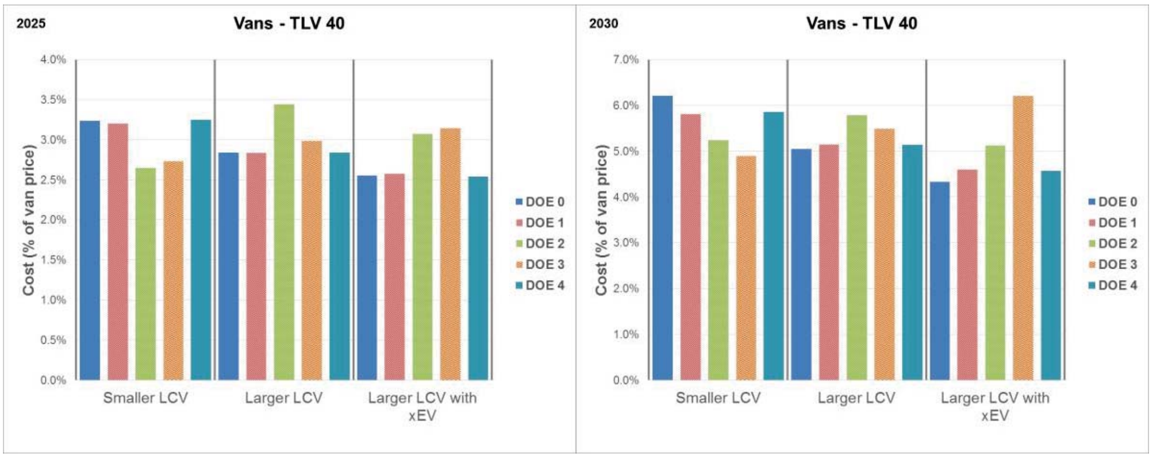


Figure 32: Additional manufacturing costs relative to vehicle price (% of van price) for categories of van manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLV40



The figures show that differences in absolute additional manufacturing costs (EUR/van) among the DOE options considered are rather limited (i.e. not more than 100 EUR/van in 2025 or 200 EUR/van in 2030).

The largest distributional impacts are seen for options DOE 2 (footprint) and DOE 3 (uniform target), where costs are significantly lower for manufacturers of smaller vans compared to the other two categories.

Only very small differences are found between options DOE 0, DOE 1 and DOE 4. In these cases, the distribution of efforts across manufacturer groups is quite homogeneous, with slightly higher costs (esp. in relative terms) for manufacturers of smaller vans and slightly higher ones for "larger LCV with xEV".

As the differences in vehicle price across the manufacturer categories are more limited than for cars, the effects are very similar when considering the cost increase relative to those prices.

As regards options DOE 3 and DOE 4, the same considerations regarding the lack of flexibility for manufacturers as regards future segmentation shifts apply as for cars.

Other considerations (for cars and vans)

From an administrative point of view, maintaining a mass based limit value curve for distributing the EU-wide fleet target is the simplest option.

As regards the slopes of the limit value curves, maintaining the values currently established in the Cars and Vans Regulation would be questionable as those slopes were specifically linked to the targets set for 2020/2021. With the switch to WLTP and the new targets to be set for post-2020, there seems to be no sound basis for simply maintaining them.

6.4.1.1.2 Social Impacts

Overall, given the limited impact on the overall costs and on the composition of the fleet, the different options considered for the distribution of effort are not expected to have significant social impacts.

There could be impacts in terms of social equity in case the distribution of effort would lead to a higher (relative) price increase for smaller or medium sized vehicles compared to premium models. However, there is no evidence available of a direct relationship between income groups and the size of vehicles purchased.

6.4.1.1.3 Environmental impacts

As the DOE options do not affect the overall CO_2 target level, they are not expected to have an impact on the overall TTW CO_2 emissions from cars and vans.

The only conceivable effect would be related to changes in the fleet composition induced by the DOE mechanism applied. Vehicles with different powertrains may be impacted differently by these options, e.g. due to differences in utility (mass or footprint), where such parameter is used for the limit value curve. For example, electric vehicles tend to be heavier than ICEV, and diesel cars tend to be heavier than petrol cars, and using a mass based DOE approach would thus tend to favour the market uptake of those types of vehicles, which in turn may impact the environmental performance of the fleet.

6.5 ZEV/ LEV incentives

6.5.1 Introduction and methodological considerations

As a manufacturer's CO_2 targets apply for its fleet-wide sales-weighted average emissions, the share of LEV within the fleet directly affects the emission reductions needed for the other vehicle types. Therefore, the impacts of the options concerning the LEV incentives cannot be considered in isolation from those regarding the EU-wide fleet CO_2 target. This is why in this Section the impacts are shown for the different LEVD/LEVT options in combination with the TLC/TLV options. In order to keep the number of combinations manageable, only some of the TLC/TLV options were selected, reflecting a range of fleet-wide CO_2 target levels.

It has been assumed that the LEV incentive level set would be met by all manufacturers[190], both in case of a binding LEV target (option LEVT_MAND) and in case of a benchmark used in a crediting system (options LEVT_CRED). However, for option LEVT_CRED, it was also assessed how the impacts would change in case the LEV benchmark would not be reached or would be overachieved.

As described in Section 5.3.1, targeted LEV incentives would provide a clear pathway for the automotive sector and public authorities towards the development of an EU market for these vehicles, thus fostering the required investments in vehicle technology and refuelling and recharging infrastructure. Starting from a rather low base, the accelerated uptake of LEV is expected to yield significant economies of scale, hence bringing down vehicle costs and making LEV more attractive for consumers. Analysts project that the faster the market grows, the faster costs could come down (see references in Section 5.3.1).

Therefore, the methodological approach reflects that costs are correlated with deployment rates, and with additional enabling policies such as the provision of electric charging infrastructure (reducing range anxiety and enhancing consumer acceptance) and measures supporting the development of an industrial battery value chain.

These effects have been captured in particular through the assumptions on the evolution of the battery costs, which are projected to decrease at a faster rate when regulatory LEV incentives are provided, thanks to the economies of scale and enhanced learning rates.

As a consequence, the following technology cost assumptions were used for the analysis of the options in this Section (see also Section 6.3.2):

- "Medium": Medium costs for all technologies – this was used for option LEV0;
- "VLxEV": Very Low costs for EV, i.e. based on battery pack costs of around 100 EUR/kWh in 2025 and 65 EUR/kWh in 2030 and Medium costs for ICEV – this was used for options LEV%_A, LEV%_B and LEV%_C (see below).

The assessment below does not include the cost of the flanking measures to support the higher uptake of more efficient vehicles, in particular zero- and low-emission vehicles. Information on the costs for the alternative fuels infrastructure can be found in the Communication 'Towards the broadest use of alternative fuels - an Action Plan on

190 As PRIMES-TREMOVE does not model the fleet of individual manufacturers, the situation where the LEV level is "met by all manufacturers" in the model context means that the share of LEV in the EU-wide new vehicle fleet equals the LEV target/benchmark.

Alternative Fuels Infrastructure'[191]. The costs for EU-wide demand side measures (Clean Vehicles Directive, Eurovignette Directive) can be found in the respective Impact Assessment reports[192].

6.5.2 Passenger cars: assessment of options with additional incentives for low-emission vehicles

In order to accelerate the sales of the most advanced low emission vehicles in the EU, additional incentives can be set. As part of an industrial policy an additional strong market signal could be sent to consumers and manufacturers. This would increase uptake and allow industry and consumers to reap economies of scale.

Table 37 shows in the first column (option LEV0) that without an additional market signal the share of LEV in the new passenger car fleet would only be determined by the EU-wide CO_2 target. For example, in 2025, the ZEV share would range between 5% and 7 % increasing with the CO_2 target level as already highlighted in Section 6.3.2.

It should be noted that a low emission vehicle is defined differently across the three options LEVD_ZEV, LEVD_25 and LEVD_50, i.e. the LEV shares cannot be directly compared between those three options because of the different coverage of vehicle types[193].

Table 37 also shows the different LEV mandate or benchmark levels for the years 2025 and 2030. For example, for zero emission vehicles (ZEV) sales would be raised to 10%, 15% or 20% in 2025, and to 15%, 20% or 25% in 2030.

It can be seen that LEV mandate or benchmark levels were selected as an incremental increase in the order of around 5% from the LEV0 fleet shares, which broadly mirrors the recent announcements by many EU manufacturers as regards their expected LEV uptake for the coming decade (see Table 4 in Section 5.3.1).

Table 37: Overview of the share (%) of LEV in the new car fleet in 2025 and 2030 when no LEV incentive is applied (LEV0) and with three different LEV mandates/benchmarks in 2025 and 2030 for different combinations of LEV definitions (LEVD) and CO_2 target levels (TLC)

<table>
<tr><th rowspan="2">LEVD_ZEV</th><th colspan="4">2025</th><th colspan="4">2030</th></tr>
<tr><th>LEV0</th><th>LEV%_A</th><th>LEV%_B</th><th>LEV%_C</th><th>LEV0</th><th>LEV%_A</th><th>LEV%_B</th><th>LEV%_C</th></tr>
<tr><td>TLC20</td><td>5%</td><td rowspan="4">10%</td><td rowspan="4">15%</td><td rowspan="4">20%</td><td>8%</td><td rowspan="4">15%</td><td rowspan="4">20%</td><td rowspan="4">25%</td></tr>
<tr><td>TLC25</td><td>5%</td><td>8.5%</td></tr>
<tr><td>TLC30</td><td>5.5%</td><td>9%</td></tr>
<tr><td>TLC40</td><td>7%</td><td>12%</td></tr>
</table>

LEVD_25	**2025**	**2030**

[191] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Towards the broadest use of alternative fuels – an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks unde rARticle 10(2) of Directive 2014/94/EU.

[192] http://ec.europa.eu/transparency/regdoc/?fuseaction=ia

[193] For option LEVD_50, the shares shown in Table 37 do not represent the actual market share of LEV because of the counting of LEV on the basis of their CO_2 emissions, as explained in Section 5.3.2.1 (Table 5)

	LEV0	LEV%_A	LEV%_B	LEV%_C	LEV0	LEV%_A	LEV%_B	LEV%_C
TLC20	8%	15%	20%	25%	12%	25%	30%	35%
TLC25	8%				12.5%			
TLC30	8.5%				13%			
TLC40	12%				20.5%			

LEVD_50	2025				2030			
	LEV0	LEV%_A	LEV%_B	LEV%_C	LEV0	LEV%_A	LEV%_B	LEV%_C
TLC20	7%	15%	20%	25%	10.5%	25%	30%	35%
TLC25	7%				11%			
TLC30	7%				12%			
TLC40	10%				17.5%			

Furthermore, in order to reach these higher sales levels, as explained in Section 5.3.2.2, three different LEV incentive policy instruments are being considered:

(i) binding mandate (LEVT_MAND);

(ii) crediting system with a one-way CO_2 target adjustment (LEVT_CRED1);

(iii) crediting system with a two-way adjustment (LEVT_CRED2).

6.5.2.1 Economic impacts

For the assessment of the economic impacts of the LEV incentives options, the same indicators are used as for assessing the options regarding the EU-wide CO_2 target levels (TLC) (see Section 6.3.2.2).

Below, the net savings achieved under the different LEV incentives options are summarised for the indicator "TCO-15 years". The results for the other indicators regarding net economic savings from a societal perspective and net economic savings over the first five years were very similar.

The detailed results for all options and indicators as well as the results of a sensitivity analysis varying the cost assumptions for the battery are provided in Annex 8.

TCO-15 years (vehicle lifetime)

Figure 33 shows the net economic savings, taking into account capital costs, O&M costs and fuel costs, over the lifetime of an "average" passenger car registered in 2025 or in 2030 for the different LEV incentive options as regards the definition (LEVD) and target/benchmark level (LEV%), in combination with four different options for the EU-wide CO_2 target level (TLC20, TLC25, TLC30 and TLC40). The net savings are calculated as the difference with the baseline.

The key general trends observed can be summarised as follows.

Firstly, all options considered bring net economic savings over the vehicle lifetime. Depending on the option, net savings per car are up to about 1,000 EUR in 2025 and up to about 2,400 EUR in 2030, and they increase with increasingly strong CO_2 target levels.

Both the fuel savings and the capital costs are key factors as regards the net savings achieved. The capital costs of LEV, and in particular of ZEV, are mainly determined by the cost of batteries and, as explained above, these are set to decrease with the introduction of additional LEV incentives creating economies of scale.

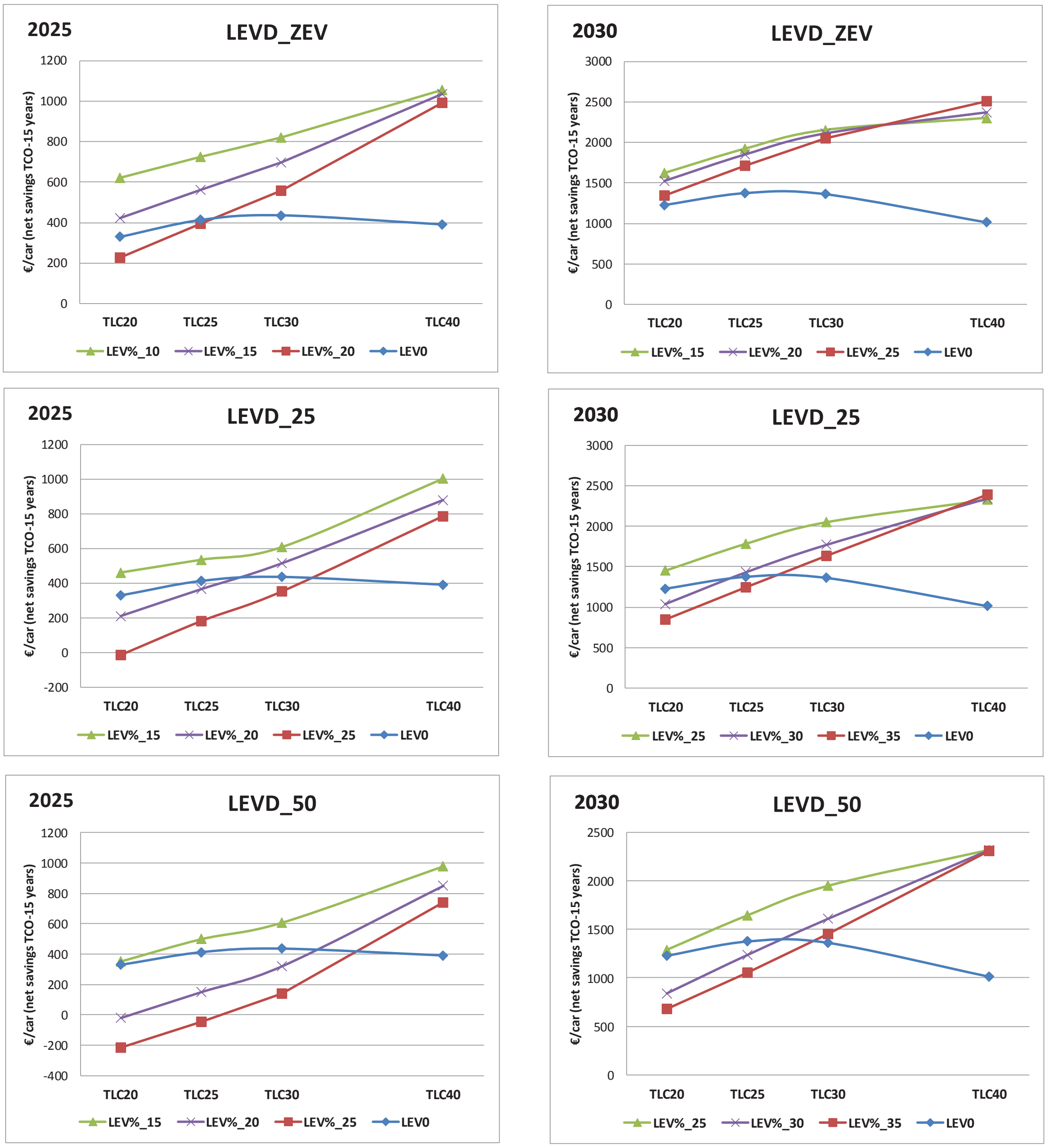
Secondly, in 2030 net economic savings are highest for the options with the lower LEV incentive compared to the other options, i.e. higher LEV incentives and LEV0.

In some cases, the higher LEV incentives have lower net economic savings than the option LEV0 without an additional incentive, e.g. in 2030 for TLC20 combined with LEVD_25 or LEVD_50 and for TLC25 combined with LEVD_50.

More generally, for TLC20 the potential net savings in case of a LEV mandate or crediting system are much lower, or slightly negative. This is not surprising: in order to reach the lowest CO_2 target combined with a LEV mandate or crediting system, higher PHEV and BEV uptake would substitute for the wide deployment of the least costly less advanced ICEV technologies.

The results for 2025 are largely similar as for 2030.

Figure 33: TCO-15 years (vehicle lifetime) (net savings in EUR/car for 2025 and 2030) for different LEV incentive options



In terms of the policy instrument chosen to reach the higher sales levels, the first option, i.e. the binding mandate, will deliver if combined with a strong enough compliance system. However, this situation could be different in the case of the crediting system which, in principle, leaves more flexibility to car manufacturers tailored to their own sales and innovation strategy.

Compared to a crediting system, a binding mandate reduces the flexibility for manufacturers to react to changes in relative costs between LEV/ZEV and conventional technologies. If e.g. battery costs decrease faster than expected, a crediting system offers stronger incentives to invest further in LEV/ZEVs and increase further the competitiveness of the European automotive industry in this technology. A pure binding mandate does not offer these flexibilities and scores therefore lower in terms of efficiency and proportionality.

Under the two crediting options, LEVT_CRED1 and LEVT_CRED2, the LEV benchmark would be non-binding, which means that it may be over- or underachieved by individual manufacturers or pools, and this will affect their fleet-wide CO_2 target as explained in Section 5.3.2.2.

The economic impacts of these options will depend on the extent to which the LEV share of different manufacturers will be above or below the LEV benchmark in 2025 and 2030.

As the strategic choices that will be made by individual manufacturers are not known in advance, numerous variants could be designed in terms of LEV share and, consequently, the corresponding CO_2 target.

In order to understand the overall bandwidth and the potential trade-offs, a "low LEV" case, where the average LEV fleet share is **below** the LEV benchmark, and a "high LEV" case, where the average LEV fleet share is **above** the LEV benchmark, will be further analysed.

The figures below are examples with the aim of illustrating how the economic impacts of options LEVT_CRED1 and LEVT_CRED2 could evolve in case the LEV benchmark set is not met at the level of the EU-wide fleet.

Figure 34 illustrates the effects on net savings for TCO-15 years which could be expected in case of a **two-way** adjustment of the CO_2 target level (option LEVT_CRED2). It shows the situation for 2030 with a CO_2 target as under option TLC30 and the lower benchmark of option LEV%_A[194].

Under this option, net savings will tend to evolve between the situation where the LEV benchmark is exactly met (point A) and the "end points" for the "low LEV" case (point B) or "high LEV" case (point C). In this case, the tightening or relaxation of the CO_2 target will be limited to a maximum of 5%, which determines the two end points of the possible range.

In case the overall LEV fleet share is below the LEV benchmark, net savings will evolve towards point B as the EU-wide fleet CO_2 target becomes up to 5% stricter, while the market penetration of LEV decreases and would become too low to create economies of scale. As a result of this, battery costs would be higher than in case the LEV benchmark is met.

In case the manufacturer reaches an overall LEV share in the fleet that is higher than the LEV benchmark, the net savings will evolve towards point C with increasing LEV fleet shares as the EU-wide fleet CO_2 target becomes up to 5% less strict, but the market uptake of LEV increases.

Figure 35 illustrates the expected impacts on net savings (TCO-15 years) in case of option LEVT_CRED1 (**one-way** adjustment of the CO_2 target level).

Under this option, the situation is the same as for LEVT_CRED2 in case the overall LEV share in the fleet is higher than the LEV benchmark (point C).

However, in case the overall LEV fleet share is below the LEV benchmark, net savings will evolve towards point B, as the initial CO_2 target level is not tightened. As for LEVT_CRED2, battery costs would be higher than in case the LEV benchmark is met.

[194] This means a LEV benchmark of 15% in case of LEVD_ZEV and 25% in case of LEVD_25 and LEVD_50 (green lines in the figures)

As can be seen, for the situation shown, the net savings would always tend to decrease in case the LEV benchmark is not met.

Furthermore, under option LEVT_CRED1, the one-way adjustment mechanism weakens the signal provided to the market as regards the uptake of LEV. Indeed, as there would be no consequences for manufacturers in not achieving the LEV benchmark, the LEV benchmark would become fully voluntary.

Figure 34: Illustration of the impacts of option LEVT_CRED2 (net savings, TCO-15 years) in case the LEV benchmark is not exactly met (with the CO_2 target of option TLC30 and the benchmark of option LEV%_A)

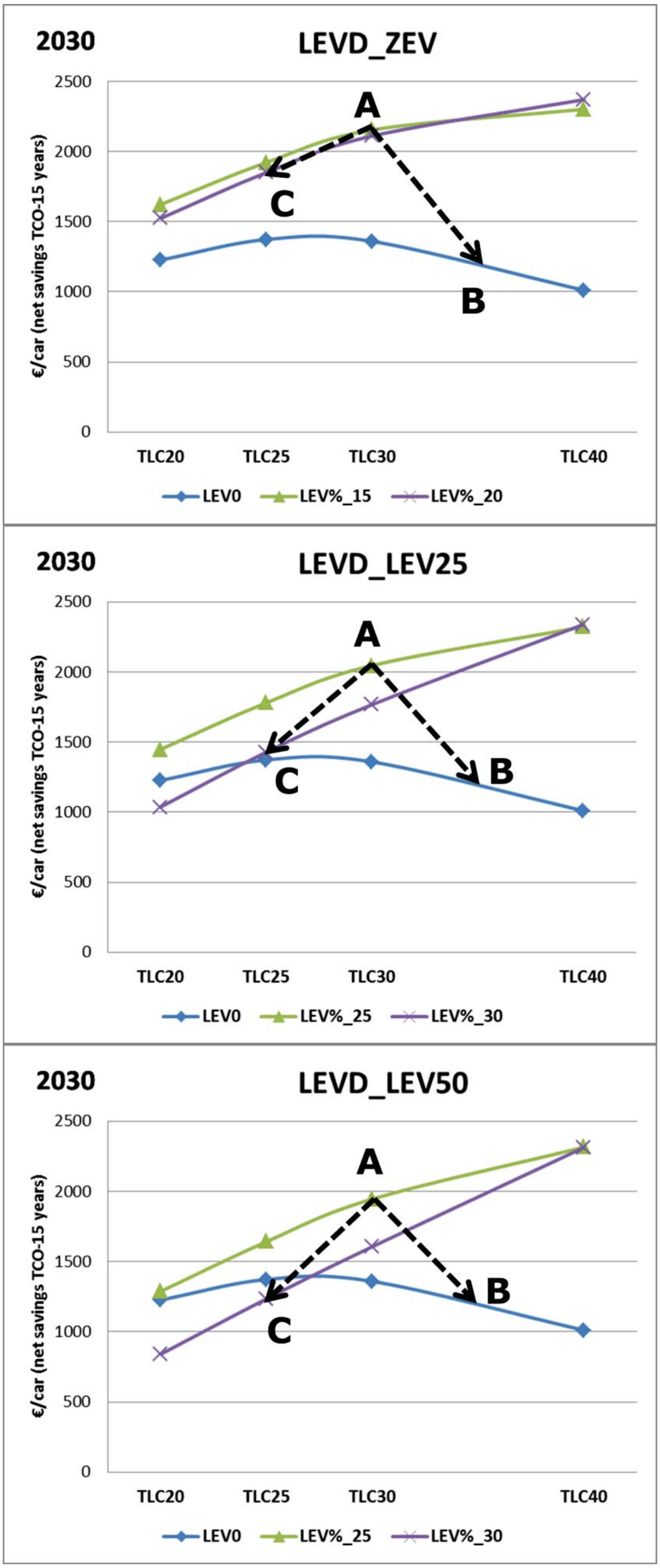
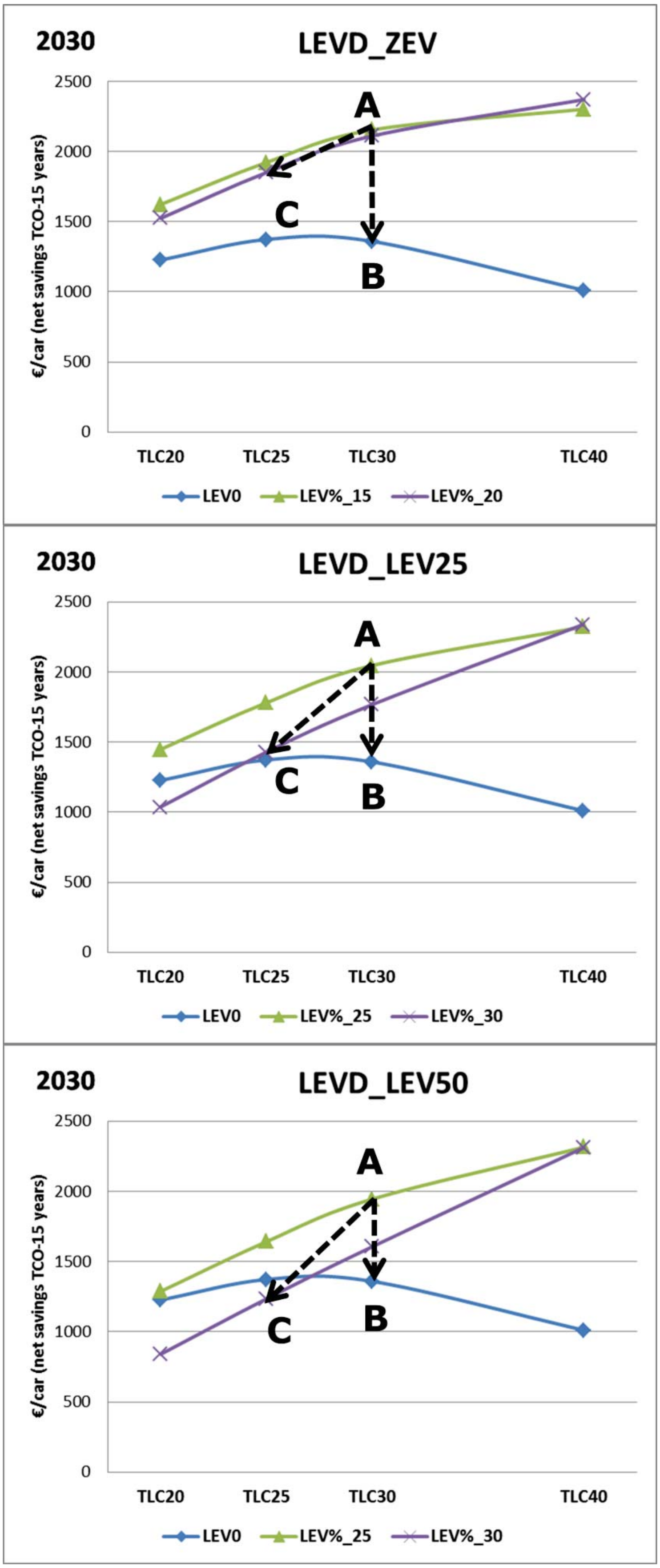


Figure 35: Illustration of the impacts of option LEVT_CRED1 (net savings, TCO-15 years) in case the LEV benchmark is not exactly met (with the CO_2 target of option TLC30 and the benchmark of option LEV%_A)



Interaction between the LEV/ZEV crediting system and the CO_2 fleet-wide reduction level

The CO_2 fleet-wide reduction level and the level of the ZEV/LEV benchmark in the case of the crediting system will also have an impact on the efficiency of the conventional vehicles. Setting a LEV incentive increases the market uptake of LEV. As a consequence, in order to comply with the CO_2 fleet-wide target, lower efforts are required to improve the efficiency of the conventional vehicles.

Table 38 shows the changes in percentages of the emissions of an average conventional car in 2030 compared with the average baseline conventional vehicle in 2020/2021 when combining the CO_2 fleet target of 25% or 30% reduction with a LEV mandate or with a LEV crediting system.

It shows that the efforts required for conventional vehicles would be significantly lower in case of a crediting system with a 5% overachievement of the LEV benchmark. As a matter of fact, CO_2 emissions of the average conventional vehicle could be relaxed and become 2 to 12% higher in case of a 25% reduction target. For a 30% reduction target, the range of changes in emissions would be from -5 to +5%.

In the other case of 5% underachievement of the LEV benchmark, manufacturers would have to significantly reduce CO_2 emissions from their conventional vehicles as indicated in Table 38: average emissions would be 12% or 18 % lower than for the baseline vehicle, in case of a 25% and a 30% reduction target, respectively. This would give quite a strong signal to manufacturers to reach the LEV benchmark and would have to be considered when designing the trade-off between the level of underachievement and the corresponding adjustment of the CO_2 target.

In a situation with a LEV mandate, CO_2 emissions of the average conventional vehicle are between 3 and 7% and between 8 and 13% lower than for the baseline vehicle, in case of a 25% and a 30% reduction target, respectively.

So, in a number of the options below there would be no incentive left for the technological advancement of internal combustion engines after 2020/21. This will have to be taken into consideration as part of the wider industrial policy when designing the trade-off between the percentage of over achievement and the credit in terms of lowering the CO_2 target.

Table 38: Emissions of an average conventional car in 2030 - expressed as % difference compared with a baseline conventional car in 2020/2021 - under options TLC25 and TLC30 in case of a LEV mandate (LEV%_A) and in case of a crediting system, with 5% overachievement of the LEV benchmark

LEVD_ZEV	**TLC25**	**TLC30**
LEVT_MAND	-7%	-13%
LEVT_CRED with 5% overachievement of the benchmark	+2%	-5%
LEVT_CRED with 5% underachievement of the benchmark	-12%	-18%

LEVD_25	TLC25	TLC30
LEVT_MAND	-4%	-10%
LEVT_CRED with 5% overachievement of the benchmark	+9%	+2%
LEVT_CRED with 5% underachievement of the benchmark	-12%	-18%

LEVD_50	TLC25	TLC30
LEVT_MAND	-3%	-8%
LEVT_CRED with 5% overachievement of the benchmark	+12%	+5%
LEVT_CRED with 5% underachievement of the benchmark	-12%	-18%

Macroeconomic assessment, including employment

The assessment of the macro-economic impacts of the options regarding LEV/ZEV incentives is done at the level of the light-duty vehicles as a whole and this is presented in Section 6.5.4.

Energy system impacts

The final energy demand from passenger cars in 2030 shows limited variation amongst the different options considered for the LEV incentives (including LEV0).

The increased market penetration of electrically chargeable vehicles (BEV, PHEV) leads to higher shares of electricity in the final energy demand for transport. Nevertheless, as illustrated in Table 39, these effects remain rather limited across the range of options considered.

Table 39: Electricity share in the final energy demand for passenger cars

Option for EU-wide fleet CO_2 target level	LEV0		Other LEV options (various LEVT, LEVD, LEV%)	
	2025	2030	2025	2030
TLC20	0.7%	1.8%	Up to 1.6%	Up to 4%
TLC25	0.7%	1.9%	Up to 1.6%	Up to 4%
TLC30	0.7%	2.0%	Up to 1.6%	Up to 4%
TLC40	0.7%	2.6%	Up to 1.8%	Up to 4.5%

The share of cars and vans in the total EU-28 electricity consumption is shown in Table 9 (Section 6.3.2.2.1.4).

Administrative burden

The different options considered as regards the ZEV/LEV incentives would not create significant additional administrative costs.

In case of a binding mandate (LEVT_MAND), an additional dedicated regime would need to be established to allow verifying whether individual manufacturers comply with the mandatory LEV share.

In contrast, under a crediting system (LEVT_CRED), compliance checking would only be against the CO_2 target.

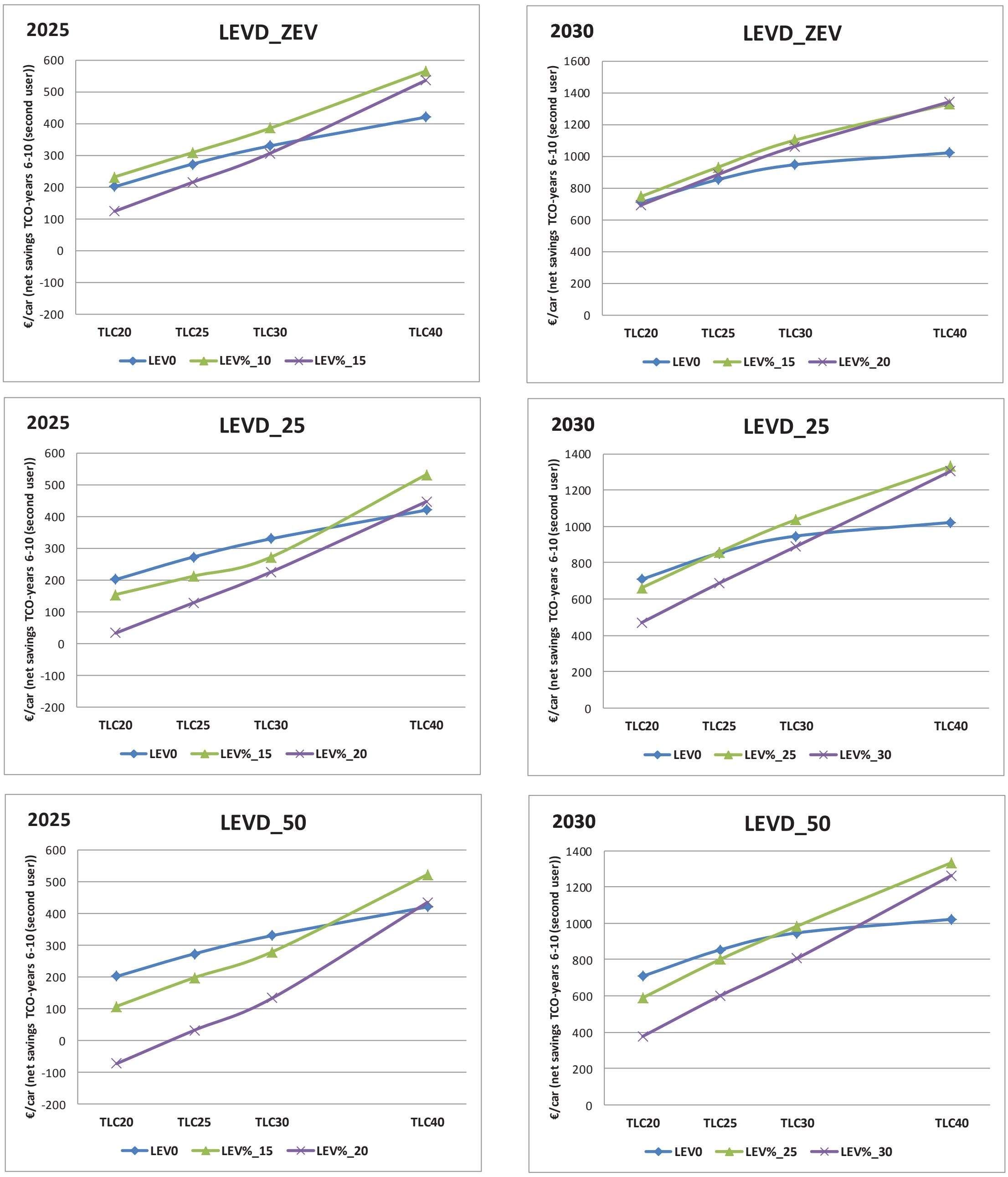
6.5.2.2 Social Impacts

As for the assessment of the options regarding the EU-wide CO_2 targets (TLC), the TCO (net savings) for the second user was used as an indicator for quantifying the social impacts of the LEV incentives options.

The figures below show the results for an "average" passenger car newly registered in 2025 or 2030.

The general findings are similar to those discussed in relation to the economic impacts (see Section 6.5.2.1). However, the differences between the various scenarios in the absolute net savings per car tend to be lower when looking at the TCO for the second user compared to the vehicle lifetime (TCO-15 years).

Figure 36: TCO-second user (years 6-10) (EUR/car) in 2025 and 2030 for different LEVD/LEVT options



6.5.2.3 Environmental impacts

CO_2 emissions (tailpipe)

The different options for the LEV incentives show variations in the tailpipe CO_2 emission levels as shown in the table below. The emissions are mainly determined by the EU-wide fleet CO_2 target, but also the fleet composition has an effect due to the differences in the gap between test and real word emissions.

Table 40: CO_2 emission reductions (%) between 2005 and 2030 (passenger cars)

Option for EU-wide fleet CO_2 target level	**LEV0**	**Other LEV options (various LEVT, LEVD, LEV%)**
TLC20	30%	32.2% - 32.4%
TLC25	30.5%	32.2% - 32.4%
TLC30	31%	32.2% - 32.4%
TLC40	33.6%	34.4% - 34.6%

Impacts of options LEVT_CRED in case the LEV benchmark is not met or overachieved

As explained in Section 5.3.2.2, in case of a LEV crediting system, the EU-wide fleet CO_2 target may vary depending on whether the LEV benchmark is under- or overachieved. The adjustment of the CO_2 target is however limited to a maximum of 5%. Therefore, the "end points" for the LEVT_CRED options as regards the environmental impact in terms of CO_2 tailpipe emissions would be similar as for the TLC options with a CO_2 target that is 5% higher, respectively 5% lower (only in case of LEVT_CRED2) than in the corresponding LEVT_MAND option[195]. These impacts can be derived from the results shown in Section 6.3.2.4.1.

Air pollutant emissions

The LEV incentives options lead to somewhat lower air pollutant emissions, in particular due to the higher market shares of ZEV. As shown in Table 41 and Table 42, emission reductions of NO_x and $PM_{2.5}$ over the period 2020-2030 show rather limited variation among the different LEV incentive options considered.

Table 41: NO_x emission reductions (%) between 2020 and 2030 (passenger cars)

Option for EU-wide fleet CO_2 target level	**LEV0**	**Other LEV options (various LEVT, LEVD, LEV%)**
TLC20	38%	42% - 46%
TLC25	38.5%	42% – 46%
TLC30	39%	42% – 46%
TLC40	42%	44% - 46%

Table 42: PM2.5 emission reductions (%) between 2020 and 2030 (passenger cars)

Option for EU-wide fleet CO_2 target level	**LEV0**	**Other LEV options (various LEVT, LEVD, LEV%)**
TLC20	34%	38% - 42%
TLC25	34.5%	38% - 43%
TLC30	35%	38% - 43%
TLC40	38%	40% - 43%

[195] "corresponding" in the sense that the CO_2 target would be the same in case the LEV benchmark is exactly met

6.5.3 *Vans: assessment of options with additional incentives for low-emission vehicles*

Similarly to passenger cars (Section 6.5.2), additional incentives were considered in order to accelerate the sales of low emission vans.

Table 43 shows in the first column (option LEV0) the share of LEV in the new van fleet, which without an additional market signal would only be determined by the EU-wide CO_2 target. For example, in 2025, the ZEV share would range between 2.5% and 3.5 % increasing with the CO_2 target level as already highlighted in Section 6.3.2.

It should be noted that a low emission van is defined differently across the three options LEVD_ZEV, LEVD_40 and LEVD_50, so the LEV shares cannot be directly compared between those three options because of the different coverage of vehicle types.

Table 43 also shows two different LEV mandate or benchmark levels, (options LEV%_A and LEV%_B) for the years 2025 and 2030. For example, for zero emission vehicles (ZEV) sales would be raised to 10% or 15% in 2025, and to 15% or 20% in 2030.

Table 43: Overview of the share (%) of LEV in the new van fleet in 2025 and 2030 when no LEV incentive is applied (LEV0) and of two LEV mandates/benchmarks in 2025 and 2030 for different combinations of LEV definitions (LEVD) and CO_2 target levels (TLV)

LEVD_ZEV	**2025**			**2030**		
	LEV0	**LEV%_A**	**LEV%_B**	**LEV0**	**LEV%_A**	**LEV%_B**
TLV20	2.5%			3.5%		
TLV25	2.7%	10%	15%	3.7%	15%	20%
TLV40	3.5%			5.5%		

LEVD_40	**2025**			**2030**		
	LEV0	**LEV%_A**	**LEV%_B**	**LEV0**	**LEV%_A**	**LEV%_B**
TLV20	10.5%	15%	20%	17.5%	25%	30%
TLV25	11.5%			18.5%		
TLV40	16.5%	20%	25%	30%	35%	40%

LEVD_50	**2025**			**2030**		
	LEV0	**LEV%_A**	**LEV%_B**	**LEV0**	**LEV%_A**	**LEV%_B**
TLV20	4.5%			7.5%		
TLV25	5%	15%	20%	8%	25%	30%
TLV40	7.5%			12.5%		

In order to reach these higher sales levels, as explained in Section 5.3.2.2, three different LEV incentive policy instruments are being considered:

(i) binding mandate (LEVT_MAND);

(ii) crediting system with a one-way CO_2 target adjustment (LEVT_CRED1);

(iii) crediting system with a two-way adjustment (LEVT_CRED2).

6.5.3.1 Economic impacts

For the assessment of the economic impacts of the LEV incentives options, the same indicators are used as for the assessing the options regarding the EU-wide CO_2 target levels (TLV) (see Section 6.3.2.2.2).

Below, the net savings achieved under the different LEV incentives options are summarised for the indicator TCO-15 years. The results for the other indicators (net economic savings from a societal perspective and net economic savings over the first five years) were very similar.

The detailed results for all options and indicators are provided in Annex 8.

TCO-15 years (vehicle lifetime)

Figure 37 shows the net economic savings taking into account capital costs, O&M costs and fuel costs over the lifetime of an "average" van in 2025 and 2030 for the different LEV incentive options as regards the definition (LEVD) and target/benchmark level (LEV%), in combination with three different options for the EU-wide CO_2 target level (TLV20, TLV25 and TLV40). The net savings are calculated as the difference with the baseline.

The key general trends observed can be summarised as follows.

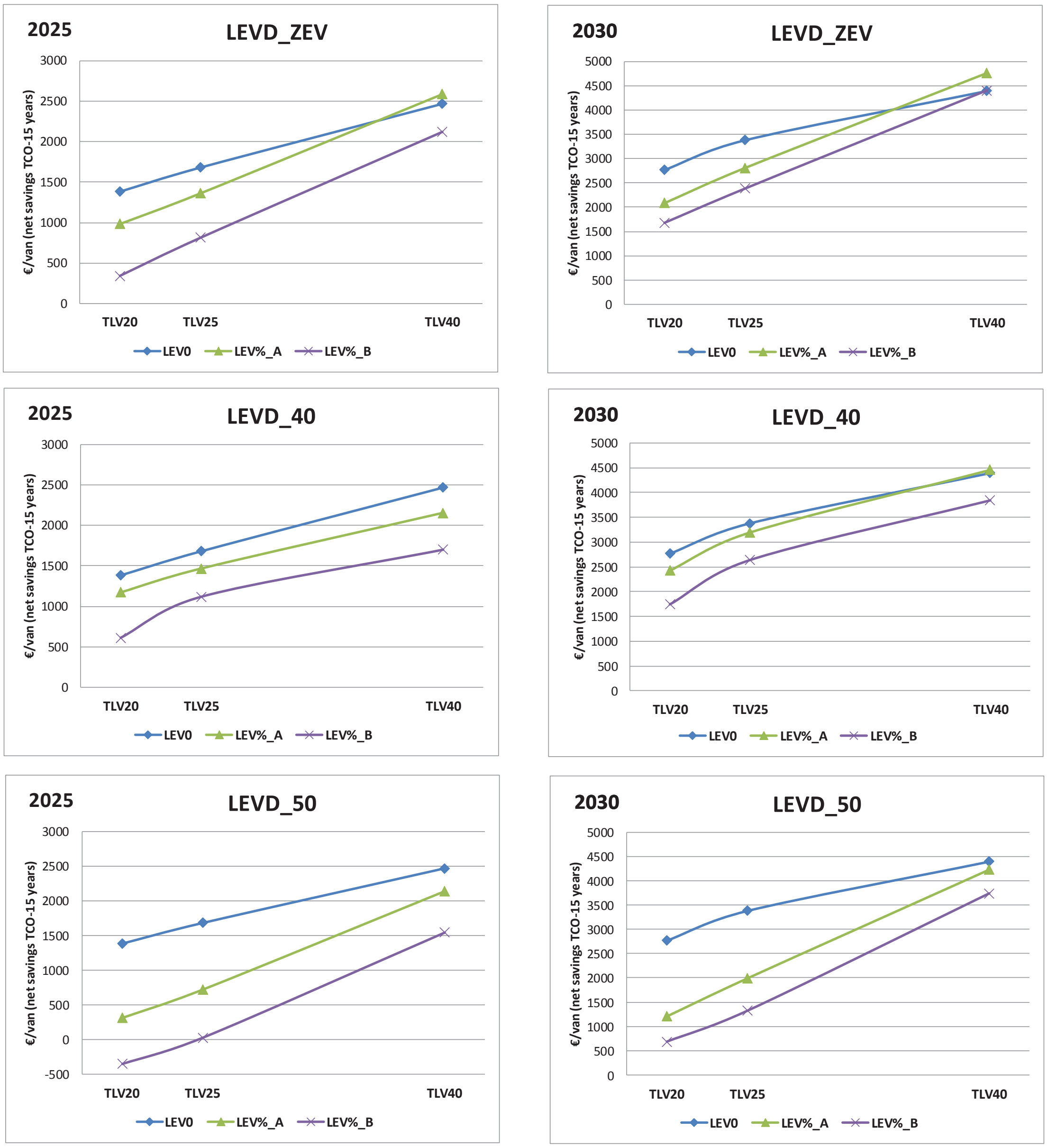
Firstly, and very different from the results for passenger cars, both for 2025 and for 2030 in all cases with one exception the option where no incentives are set (LEV0) shows the highest net economic savings compared to the options with additional incentives for ZEV/LEV. Furthermore, the net savings are higher for the lower levels of the LEV mandate/benchmark (option LEV%_A).

Still, all options considered with only one exception bring net economic savings over the vehicle lifetime. Depending on the option, net savings are up to about 2,500 EUR for a 2025 new van and up to about 4,500 EUR for a 2030 new van.

Both fuel savings and capital costs are key factors as regards the net savings achieved. The capital costs of LEV, and in particular of ZEV, are mainly determined by the cost of batteries and, as explained above, these are set to decrease with the introduction of LEV incentives creating economies of scale.

Secondly, with rising CO_2 fleet-wide targets from TLV20, TLV25 to TLV40 also the net economic savings increase.

Figure 37: TCO- 15 years (EUR/van) in 2025 and 2030 for different LEVD/LEVT options



Impacts of options LEVT_CRED (1 and 2) in case the LEV benchmark is not exactly met

Under the two crediting system options LEVT_CRED1 and LEV_CRED2, the LEV benchmark would be non-binding, which means that it may be over- or underachieved by individual manufacturers (or pools), which would affect the fleet-wide CO_2 target as explained in Section 5.3.2.2. Thus, the economic impacts of this option will depend on the extent to which the LEV share of different manufacturers is higher or lower than the LEV benchmark in 2025 or 2030.

As the strategic choices that would be made by individual van manufacturers in this respect are not known, for the purpose of the analysis numerous variants could be designed in terms of LEV share and, consequently, CO_2 target.

However, since the economic analysis above showed that the option without an additional LEV incentive is economically superior compared to the ones with a crediting system, van manufacturers would most likely not voluntarily increase sales of low emission vans to reach or even overachieve the benchmark. This means that given the underlying economics setting a voluntary LEV benchmark would most likely not create the necessary incentivising effect.

Energy system impacts

The final energy demand from vans in 2030 shows limited variation amongst the different options considered for the LEV incentives (including LEV0).

The increased market penetration of electrically chargeable vehicles (BEV, PHEV) leads to higher shares of electricity in the final energy demand for transport. Nevertheless, as illustrated in the table below, these effects remain rather limited with respect to the total energy demand of vans across the range of options considered.

Table 44: Electricity share in the final energy demand of vans

Option for CO_2 target level	LEV0		Other LEV options (various LEVT, LEVD, LEV%)	
	2025	2030	2025	2030
TLV20	0.4%	1.5%	1% - 1.4%	2.5% - 4.7%
TLV25	0.5%	1.6%	0.9% -1.8%	2.5% - 4.7%
TLV40	0.7%	2.3%	1.1% -2.3%	2.9% - 6.1%

Light Duty Vehicle Electricity consumption

Table 45 shows the share of the total EU-28 electricity consumption used by cars and vans in 2025 and 2030 for selected policy options. It illustrates that, even with the highest LEV mandates/benchmarks considered, the share of electricity used by LDV up to 2030 is not more than a few percent of total electricity consumption.

Table 45: Electricity consumption by cars and vans with respect to total electricity consumption (EU-28) under different options for the EU-wide CO_2 target and LEV incentives

Options		Share of cars and vans in total electricity consumption	
cars	vans	**2025**	**2030**
TLC30, LEV%_B	TLV25, LEV%_B	1.0%	2.5%
TLC40, LEV%_B	TLV40, LEV%_B	1.4%	3.0%

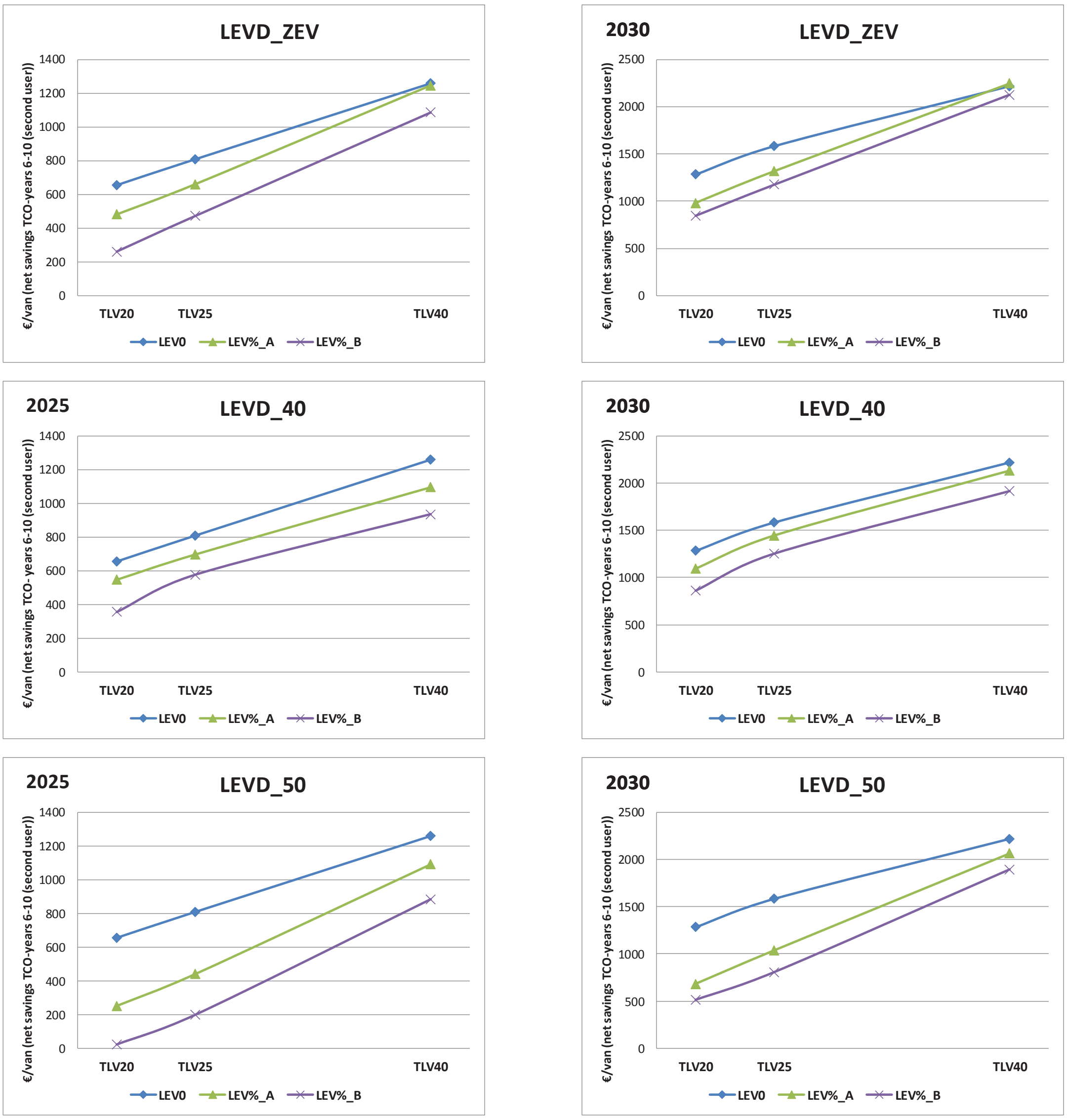
6.5.3.2 Social Impacts

As for the assessment of the options regarding the EU-wide CO_2 targets (TLV, see Section 0) the TCO (net savings) for the second user of vans will be used as an indicator for quantifying the social impacts of the LEV incentives options.

The figure below shows the results for an "average" van newly registered in 2025 or 2030.

The general findings are similar to those discussed in relation to the economic impacts (see Section 6.5.3.1). However, the differences between the various scenarios in the absolute net savings per car tend to be smaller when looking at the TCO for the second user compared to the vehicle lifetime (TCO-15 years).

Figure 38: TCO-second user (years 6-10) (EUR/van) in 2025 and 2030 for different LEVD/LEVT options



6.5.3.3 Environmental impacts

CO_2 emissions (tailpipe) of vans

The different options for the LEV incentives show variations in the tailpipe CO_2 emission levels as shown in the table below. The emissions are mainly determined by the EU-wide fleet CO_2 target, but also the fleet composition has an effect due to the differences in the gap between test and real word emissions.

Table 46: CO_2 emission reduction (%) between 2005 and 2030 (vans)

Option for EU-wide fleet CO_2 target level	LEV0	Other LEV options (various LEVT, LEVD, LEV%)
TLV20	22.2%	26.1%-26.7%
TLV25	22.6%	26.3% -26.7 %
TLV40	26.4%	27.4% - 31.3%

Impacts of options LEVT_CRED in case the LEV benchmark is not exactly met

As explained in Section 5.3.2.2, for options LEVT_CRED1 and LEV_CRED2, the EU-wide fleet CO_2 target may vary depending on whether the LEV benchmark is under- or overachieved.

The adjustment of the CO_2 target is however always limited to a maximum of 5%. Therefore, the "end points" for the LEVT_CRED options in terms of CO_2 tailpipe emissions would be similar as for the TLV options with a CO_2 target that is 5% higher (for LEVT_CRED2 only), respectively 5% lower than in the corresponding LEVT_MAND option[196]. These impacts can be derived from the results shown in Section 6.3.2.4.1.

Air pollutant emissions

The LEV incentives options lead to somewhat lower air pollutant emissions, in particular due to the higher market shares of ZEV. As shown in the tables below, emission reductions of NO_x and $PM_{2.5}$ over the period 2020-2030 show limited variation among the different LEV incentive options considered.

Table 47: NO_x emission reduction (%) between 2020 and 2030 (vans)

Option for EU-wide fleet CO_2 target level	LEV0	Other LEV options (various LEVT, LEVD, LEV%)
TLV20	33%	37% - 43%
TLV25	33%	36% – 43%
TLV40	36%	38% - 45%

Table 48: PM2.5 emission reduction (%) between 2020 and 2030 (vans)

Option for EU-wide fleet CO_2 target level	LEV0	Other LEV options (various LEVT, LEVD, LEV%)
TLV20	33%	36%-42%
TLV25	33%	36% - 42%
TLV40	36%	38% - 45%

196 "corresponding" in the sense that the CO_2 target would be the same in case the LEV benchmark is exactly met

6.5.4 Macroeconomic impacts, including employment, of setting LEV incentives for cars and vans

6.5.4.1 Introduction and methodological considerations

The E3ME model was used to assess the macro-economic and sectoral economic impacts of the policy options regarding LEV incentives. A detailed description of this model is provided in Annex 4.

In the policy scenarios different incentives for LEV were considered in addition to the EU-wide fleet CO_2 target. The analysis was done for the scenario TL30c/25v, combining options TLC30 (cars) and TLV25 (vans)[197]. As regards the LEV definition, the options LEVD_25 (cars) and LEVD_40 (vans) were chosen for this analysis. As regards the LEV mandate/benchmark level, two options (LEV%_A and LEV%_B, see Section 5.3.2.2) were modelled. The scenarios modelled are summarised in Table 49.

Table 49: Overview of scenarios modelled with E3ME for assessing the macro-economic impacts of various options regarding LEV incentives

E3ME scenario	**Option for EU-wide fleet CO_2 target level**	**Option for LEV incentive definition and level**	
		Cars	Vans
TL0 (Baseline)	TLC0 and TLV0	-	-
LEV_1	TLC30 and TLV25	LEVD_25, LEV%_A	LEVD_40, LEV%_A
LEV_2		LEVD_25, LEV%_B	LEVD_40, LEV%_B

All the modelled scenarios assume that only the transport sector undergoes changes due to the new CO_2 target level and the LEV incentives. Compared to the baseline, the other sectors do not undertake higher efforts to decrease GHG emissions or increase energy savings. In this way, it is possible to isolate the macro-economic effects of the specific policy.

In all scenarios, government revenue neutrality is assumed. The implementation of the new CO_2 targets reduces petrol and diesel consumption, which are commodities upon which taxes are levied in all Member States. This is compensated, in all scenarios, by a proportional increase of VAT rates, and hence, VAT revenues.

6.5.4.1.1 GDP impacts

Table 50 shows the projected GDP impact for the EU28 for the scenarios LEV_1 and LEV_2, and for the scenario TL30c/25v (see Section 6.3.2.2.3.1), which has the same EU-wide fleet CO_2 targets, but does not foresee additional LEV incentives compared with the baseline. The results shown are based on the assumption that the battery cells used in electric vehicles are imported in the EU from third countries.

E3ME projects small positive GDP impacts for the LEV scenarios assessed, slightly more positive for the scenario with the lower mandate/benchmark levels (LEV_1).

[197] Macro-economic impacts would be very similar when combining options TLC25 (cars) and TLV25 (vans).

Setting LEV incentives also drives marginal improvements with respect to the scenario TL30c/25v starting from 2030 onwards.

Table 50: Impact on GDP (EU-28) of different options regarding the LEV incentives – battery cells imported (E3ME model)

	2025	**2030**	**2035**	**2040**
TL0 (Baseline)	16,018,660	17,087,725	18,381,955	19,892,587
TL30c/25v	0.00%	0.02%	0.03%	0.05%
LEV_1	0.00%	0.03%	0.04%	0.06%
LEV_2	-0.01%	0.02%	0.04%	0.06%

As under the LEV policy options increases also the market penetration of electrically rechargeable vehicles compared to the TL30c/25v scenario, it is relevant to consider the impact of battery cells being manufactured either inside or outside the EU.

Table 51 presents the results under the assumption that the battery cells used in electric vehicles are manufactured in the EU. It shows that the GDP increase is higher in the LEV policy options. In this case, the higher LEV mandates/benchmarks (LEV_2) lead to slightly higher positive impacts.

Table 51: Impact on GDP (EU-28) of different options regarding the LEV incentives - battery cells manufactured in EU (E3ME model)

	2025	2030	2035	2040
TL0 (baseline)	16,022,952	17,094,332	18,391,086	19,901,703
LEV_1	0.00%	0.04%	0.05%	0.05%
LEV_2	0.00%	0.04%	0.06%	0.06%

Interestingly, the pattern of GDP impacts of the different LEV incentive options is quite similar to those estimated for the different CO_2 targets (see Section 6.3.2.2.3.2).

On the positive side, there is an expansion of the automotive supply chain translated into increases in production in sectors such as rubber and plastics, metals and electrical and machinery equipment sectors reflecting the impact of increased demand from the automotive sectors for batteries and electric motors, while the automotive sector itself sees a small decrease in value added due to the decreased use of combustion engines in its cars. Similarly the power and hydrogen supply sectors see production increase, reflecting increased demand for electricity and hydrogen to power EVs, while the petroleum refining sector sees lower production.

Table 52 shows the main impacts on output by the most affected sectors in 2030 for the scenarios with the conservative assumption that all battery cells are imported from outside the EU. The other sectors see smaller but positive impacts due to the projected increased overall economic output.

Table 52: Impact on 2030 output (M€ in baseline and % change from baseline for other scenarios) for the most affected sectors (EU-28) of different options regarding the LEV incentives - battery cells imported (E3ME model)

	TL0 (M€)	TL30c/25v	LEV_1	LEV_2
Petroleum refining	410,422	-1.1%	-1.3%	-1.2%
Automotive	1,076,972	-0.1%	-0.6%	-0.9%
Rubber and plastics	317,932	0.4%	0.4%	0.4%
Metals	1,044,999	0.3%	0.3%	0.2%
Electrical equipment	1,091,185	0.9%	0.5%	0.7%
Machinery equipment	581,955	0.2%	0.3%	0.3%
Electricity, gas, water, etc.	1,124,221	0.3%	0.6%	0.7%

In case that the battery cells are manufactured in the EU, the electrical equipment sector output would show an increase of 0.6% and 0.9% with respect to the baseline in LEV_1 and LEV_2, respectively.

6.5.4.1.2 Employment

As shown in Table 53, the scenarios assessed show small positive changes in the number of jobs across the EU-28 compared to the baseline.

Table 53: Impact in terms of total employment (in thousands of jobs, EU-28, and % change to the baseline) of different LEV incentive options - battery cells imported (E3ME model)

N of jobs (000s)	2030	2035	2040
Baseline	230,207	225,871	223,148
TL30c/25v	0.01%	0.05%	0.07%
LEV_1	0.01%	0.03%	0.05%
LEV_2	< 0.01%	0.02%	0.02%

The results shown are based on the assumption that battery cells used in electric vehicles are imported in the EU from third countries and thus results would be more positive if the EU were to develop its own battery sector.

At sectoral level, similar conclusions as for the impacts on the output can be drawn. The small positive employment impacts mainly occur in sectors supplying the automotive sector as well as the power sector, while the petroleum refining and automotive sectors itself see a small negative effect. It can be noted that all the effects are slightly higher for LEV_2 with respect to LEV_1.

Table 54 shows the employment impact breakdown by sector, in the year 2030, under the conservative assumption that all battery cells are produced outside of the EU.

Table 54: Impact in terms of employment in the most affected sectors (in thousands of jobs, EU-28) of different LEV incentive options - battery cells imported (E3ME model)

2030	**Baseline** (number of jobs, 000s)	Change from baseline (%)		Change from baseline (number of jobs, 000s)	
		LEV_1	**LEV_2**	**LEV_1**	**LEV_2**
Petroleum refining	151	-0.4%	-0.3%	- 0.6	- 0.5
Automotive	2,454	-0.5%	-0.8%	- 12.3	- 19.6
Rubber and plastics	1,776	0.4%	0.4%	7.1	7.1
Metals	4,288	0.1%	0.1%	4.3	4.3
Electrical equipment	2,451	0.2%	0.3%	4.9	7.4
Machinery equipment	2,506	0.1%	0.1%	2.5	2.5
Electricity, gas, water, etc.	2,852	0.3%	0.4%	8.6	11.4
Other sectors	213,731	0.0%	0.0%	15	20

As mentioned in Section 6.3.2.2.3.3, external studies assessing the possible impacts of an accelerated uptake of low- and zero-emission vehicles also estimate an increase in overall employment.

By contrast, a study assessing the impact of a much more drastic and abrupt policy change compared to all the options analysed in this IA, i.e. a complete ban of conventional powertrains by 2030 in Germany[198] unsurprisingly concludes that jobs in SMEs are particularly at risk due to difficulties in developing alternative technologies within such a short time period. Clearly, the capacity of companies to develop new technologies and to invest in new factories strongly depends on the length of the transition time. It is therefore important to underline that the policy options considered in this impact assessment are based on an incremental technology transition instead of a rapid and very disruptive change within a short period of time. This recognises the challenges linked to the transition to new technologies for companies and the workforce.

A more detailed summary of the external studies regarding employment and qualifications is presented in Annex 7.

[198] Falck, O. et al. (2017): "Auswirkungen eines Zulassungsverbots für Personenkraftwagen und leichte Nutzfahrzeuge mit Verbrennungsmotoren" ifo institut, http://www.cesifo-group.de/portal/page/portal/DocBase_Service/studien/Studie-2017-Falck-etal-Zulassungsverbot-Verbrennungsmotoren.pdf

6.6 Elements supporting cost-effective implementation

6.6.1 Eco-innovations (ECO)

6.6.1.1 Future review and possible adjustment of the cap on the eco-innovation savings (Option ECO 1)

Environmental impacts

The cap set is intended to limit to a certain extent the eco-innovation savings that manufacturers may use to achieve their CO_2 targets as those CO_2 targets are primarily intended to stimulate the uptake of more efficient 'on-cycle' technologies, whose effect can be demonstrated in the type approval test. Without such a cap, there is a risk that the uptake of those 'on-cycle' technologies would be reduced. While off-cycle technologies contribute to improving vehicle efficiency, the highest potential for such improvements still lies in the technologies whose effect is visible in the type approval test. The cap should therefore be set so that an appropriate balance can be struck between the incentives given to on- and off-cycle technologies respectively.

For setting the cap at the appropriate level, account needs to be taken of the implementation of the WLTP and the uncertainties linked to the determination of the savings of the eligible technologies. To address this uncertainty, more data will need to become available. This includes inter alia data on the savings potential of new off-cycle technologies such as mobile air-conditioning equipment.

Economic impacts

The 7 g CO_2/km cap would allow the continuation of the current regime under WLTP test conditions. A number of studies[199] as well as the previous impact assessments undertaken in preparation of the existing Regulations[200] concluded that the eco-innovation regime would promote the development and market deployment of eco-innovative technologies that are less costly than some improvements of which the effect can be demonstrated in the test procedure.

The level of the cap may have an impact on the choice of measures taken to reduce emissions by the manufacturer. However, under the current eco-innovation regime the 7 g CO_2/km cap is far from reached, so it does not appear that maintaining this cap would constrain the uptake of more cost-effective efficiency improvements. It is however appropriate to have the possibility to further assess and, where necessary, adjust the cap allowing for the uptake of a cost-efficient mix of off-cycle and on-cycle technologies over time.

Administrative burden

There would not be any additional administrative burden resulting from this option.

Social impacts

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

[199] Ricardo-AEA and TEPR (2015), Evaluation of Regulations 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles, CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

[200] SWD(2012) 213 final

6.6.1.2 Extend the scope of the eco-innovation regime to include mobile air-conditioning (MAC) systems including a future review and possible adjustment of the cap on the eco-innovation savings (Option ECO 2)

Environmental impacts

In recent years, MAC systems have become standard equipment in practically all vehicle segments. Those systems are among the most important energy consumers on board of light-duty vehicles[201]. Making MAC systems eligible as eco-innovations would create an incentive to improve their efficiency.

While more CO_2 savings from eco-innovations would become available to manufacturers to achieve their targets, it is expected that the environmental impact would be neutral in case it can be ensured that real world CO_2 reductions are achieved by more efficient MAC devices.

Economic impacts

Efficiency improvements of MAC systems are expected to be a cost-effective option for manufacturers to reduce emissions and this would benefit consumers through improved fuel consumption of the vehicles.

Administrative burden

Inclusion of MAC systems into the eco-innovation regime would extend the scope of that regime to technologies that were not previously eligible as eco-innovations. This does not in itself increase the administrative burden of the eco-innovation regime in itself, i.e. the administrative burden of preparing the applications for the applicants and the assessment by the European Commission for preparing the Decision remains the same. It should however be noted that the procedure for application and the certification of the CO_2 savings from eco-innovations is being simplified as part of the current implementation work with the intention of reducing the administrative burden for the applicants and for national type approval authorities.

Stimulus to innovation

By making MAC systems eligible as eco-innovations, incentives will be given to both component suppliers and vehicle manufacturers to invest in further research and development, thus enhancing innovation in this technology field.

Social impacts

A better understanding of the influence of MAC systems on the overall CO_2 performance of the vehicles would also be achieved thus providing more representative environmental and fuel consumption data to the benefit of consumers.

6.6.2 Pooling (POOL)

6.6.2.1 Change nothing (Option POOL 0)

Environmental impacts

The evaluation study concluded that the pooling provisions have contributed beneficially to most of the current Regulations' objectives.

---

[201] Martin F. Weilenmann, Robert Alvarez, Mario Keller, (2010) Fuel Consumption and CO_2/Pollutant Emissions of Mobile Air Conditioning at Fleet Level – New Data and Model Comparison, (Environmental Science and Technology, 2010, 44).

Economic impacts

The evaluation study showed that pooling contributed beneficially in terms of cost-effectiveness, and competitive neutrality. Pooling facilitates compliance for those manufacturers that produce a rather limited range of vehicles, thus helping to preserve the diversity of the fleet.

Administrative burden

There would not be any additional administrative burden resulting from this option as the existing procedures are well established and fairly straightforward for manufacturers to apply.

Social impacts

The option does not present any significant social impacts.

6.6.2.2 An empowerment for the Commission to specify the conditions for open pool arrangements (Option POOL 1)

Environmental impacts

In view of the limited number of independent manufacturers that would be eligible to form an open pool, it is considered that any negative environmental impact would remain very small under this option.

Economic impact

Enhancing the possibility for independent manufacturers to pool by increasing legal certainty and improving compliance planning would contribute further to the cost-effectiveness implementation of the legislation. Furthermore, this option would improve the competitive neutrality of pooling by placing independent manufacturers in a position equivalent to those of connected undertakings.

Administrative burden

The administrative burden would decrease for manufacturers as the specified conditions would clarify the applicable rules and simplify the process of arranging open pools.

Social impacts

The option does not present any significant social impacts.

6.6.3 Trading (TRADE)

6.6.3.1 Change nothing (Option TRADE 0)

As this option implies a continuation of the current pooling regime, the impacts would be similar as described in Section 6.6.2.1

6.6.3.2 Introduce trading as an additional modality for reaching the CO_2 targets and/or LEV mandates (Option TRADE 1)

Environmental impacts

Trading as a complementary modality to pooling should not negatively affect the achievement of the EU-wide fleet CO_2 targets. Some risks associated with the trading of credits are rather linked to banking and borrowing (see section 6.6.3).

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 and/or LEVs/ZEVs in its fleet in order to comply with the set targets. By contrast, under a trading mechanism without a limit on the amount of credits to be traded per manufacturer or pool, a manufacturer or pool could decide to invest less in new technologies and instead buy credits from other manufacturers to fulfil the CO_2 target. Investments in energy-efficient vehicles and/or LEV/ZEV may be limited to only some specialised manufacturers or pools and hence possibly limit the number of manufacturers taking up innovative technologies.

Economic impacts

Trading can reduce overall compliance costs for manufacturers by providing for additional flexibility in meeting the targets. This in turn creates a potential additional revenue stream.

Compared to pooling, additional flexibility is achieved as trading does not require an upfront decision. In the case of pooling, before the end of every year manufacturers have to notify pools for the purpose of target compliance. Trading could 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.

However, these benefits depend on the liquidity in the market and the willingness of manufacturers and pools to trade. Given the relatively small number of manufacturers, in particular when a pool would act as one trading entity, a few manufacturers may dominate the market. This may limit the potential economic benefits of trading.

Administrative burden

The introduction of trading would increase the administrative burden compared to the existing flexibilities. Trading would require both manufacturers and the Commission to monitor all transactions, e.g. in the form of a register. While the number of market participants would be limited, it could increase the time needed for compliance checking as well as finalisation of annual performance data.

In the case of pools engaging in trading, changes to the pool composition over time would have to be considered when determining the available credits.

Social impacts

If trading leads to lower overall compliance costs, this may increase the net economic savings and benefits for consumers.

6.6.4 Banking and borrowing (BB)

6.6.4.1 Change nothing (Option BB 0)

Environmental impacts

The absence of banking and borrowing does not affect the effectiveness of the regulations in reducing emissions in any significant way.

Economic impacts

Requiring compliance within the defined target year(s) - without relying on past or future emission surpluses – creates certainty and predictability when to achieve the CO_2 target levels set. However, it limits flexibility for manufacturers or pools to comply with the targets and may therefore increase compliance costs.

Social impacts

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

6.6.4.2 Banking only (Option BB1)

Environmental impacts

The accumulation and carry-over of credits can undermine the effectiveness of the targets. This was experienced for example under the ZEV programme in California (see Box 2 in Section 5.3.1). A recent study[202] concluded that banked credits accumulated by manufacturers over time put at risk that the number of ZEVs to be put on the market would actually be met. In case of a too low LEV target and higher than expected supply of LEV/ZEVs, banking can even result in a shift back towards conventional ICEV[203].

To avoid such negative impacts that would weaken the CO_2 targets, the level of credits banked could be capped and credits could be set to expire after a fixed time limit. In addition, there could be rules on the maximum carry over from one compliance period to another.

Economic impacts

Allowing the banking of credits offers manufacturers greater flexibility and can therefore reduce their compliance costs, thus increasing 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 the powertrain composition of their fleet. It would also allow for dealing with unexpected annual fluctuations in a manufacturer's fleet.

Administrative burden

Administrative costs would increase as the emissions monitoring system would need to be extended to keep track of the available and used credits. In order to ensure full transparency each manufacturer's or pool's credit balance would have to be published every year. In case the composition of a pool changes during a banking period, it would be necessary to establish the correct reallocation of the credits banked as a pool to each manufacturer in the pool.

The 2012 impact assessment[204] supporting the Commission's proposals for amending the Cars and Vans Regulations also highlighted this additional administrative complication.

[202] Shulock, C. (2016): Manufacturer Sales Under the Zero Emission Vehicle Regulation (Prepared for Natural Resources Defense Council), https://www.nrdc.org/sites/default/files/media-uploads/nrdc_commissioned_zev_report_july_2016_0.pdf

[203] Element Energy (2016): "Towards a European Market for Electro-Mobility"

[204] European Commission (2012) - Commission Staff Working Document - Impact Assessment accompanying the documents "Proposal for a regulation of the European Parliament and of the Council amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars" and "Proposal for a regulation of the European Parliament and of the Council amending Regulation (EU) No 510/2011 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new light commercial vehicles" (SWD (2012)213 final)

Social impacts

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

6.6.4.3 Banking and borrowing (Option BB 2)

Environmental impacts

Overall, similar considerations apply as for option BB1, but there are some additional environmental impacts and risks when allowing borrowing. These relate in particular to manufacturers not being able to balance out a negative amount of credits at the end of the scheme's duration. [205] As for banking, negative impacts could be limited by defining a maximum amount of credits that can be borrowed. In addition, borrowing could be limited to one compliance period in order to avoid that targets are not complied with.

Economic impacts

Banking and borrowing would give additional flexibility to manufacturers as compared to Option BB 1 in that it anticipates future credits. However, the same caveats as discussed for Option BB 1 apply, including as regards the additional administrative burden.

Banking and borrowing could be of particular interest for manufacturers with a less diversified fleet which are more likely to be negatively affected by annual variations in their fleet CO_2 performance. These are however predominantly small volume manufacturers which may in any case benefit from derogations. Large volume manufacturers have generally a more diverse fleet without strong annual fluctuations.

A particular issue as regards borrowing could arise in case a manufacturer that has been borrowing credits to be used in future compliance periods would go out of business. This would create serious problems of liability for compensating the credit deficit for that period.

Social impacts

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

6.6.5 Niche derogations for car manufacturers (NIC)

6.6.5.1 Change nothing (Option NIC 0)

Environmental impacts

The main concerns identified around the current system of niche derogations are the risks of reduced effectiveness of the targets. Currently only one-third of the eligible manufacturers makes use of niche derogations, covering only one fifth of the sales of all manufacturers eligible for these derogations.[206] The environmental impact of the derogation has therefore been limited so far.

(http://eur-lex.europa.eu/resource.html?uri=cellar:70f46993-3c49-4b61-ba2f-77319c424cbd.0001.02/DOC_1&format=PDF)

[205] CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

[206] Ricardo-AEA and TEPR, 2015: "Evaluation of Regulation 443/2009 and 510/2011 on the reduction of CO_2 emissions from light-duty vehicles" (report for the European Commission, DG CLIMA)

However, if all eligible manufacturers would use niche derogations, the negative impact on the CO_2 reductions achieved under the Regulation would increase significantly and would reduce the effectiveness of the Regulation.

Furthermore, under this option, no further efficiency improvement would be required for those eligible manufacturers for the period post-2021.

Economic Impacts

The niche derogation regime has some drawbacks in terms of competitive neutrality.

Niche manufacturers are competing with those that are not eligible for the derogation in the same market segments. However, most of the niche manufacturers currently present on the EU market are major global manufacturers but with relatively small sales in the EU. This may result in a distortion of the market and may provide new entrants in the EU market with a competitive advantage[207].

Furthermore, very few of the potentially eligible manufacturers have so far made use of the derogations and most of them have emission levels similar to their 'fleet-wide target under the non-derogated regime. For those, there are limited economic benefits from seeking a niche derogation.

In addition, the use of the year 2007 to set manufacturer specific emissions baseline has distorting effects and penalizes early action. The higher its 2007 emissions, the larger the benefit for a manufacturer of making used of the niche derogation. Hence, most of the manufacturers which have applied for a niche derogation had emissions in 2007 above the fleet-wide average.

Social impacts

There are no direct or otherwise relevant social impacts of maintaining the niche derogations.

6.6.5.2 Set new derogation targets for niche manufacturers (Option NIC 1)

Environmental impacts

By setting new targets for niche manufacturers during the period 2022-2030, based on the same reduction percentage as for the overall EU-wide fleet target (taking the 2021 targets defined for each niche manufacturer individually as the starting point), emissions from those manufacturers will be further reduced in line with those of the fleet.

As the target levels get stricter, the absolute difference (in g CO_2/km) between the niche targets and the 'default' specific emission targets (without derogation) will get smaller. As a result, the impact of the derogation on the overall emission reduction will become more limited.

On the other hand, a tightening of the specific emission targets may cause more niche manufacturers to apply for this derogation. This would risk reducing the effectiveness of the legislation, as indicated in the analysis of option NIC 0.

Economic impacts

The same risks with regard to market distortion between niche and other manufacturers apply as indicated for option NIC 0.

[207] CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020, report for the European Commission (DG CLIMA)

Social impacts

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

6.6.5.3 Remove the niche derogation (Option NIC 2)

Environmental impacts

Removing the niche derogation would make all car manufacturers responsible for more than 10,000 registrations per year subject to the EU-wide fleet target, taking into account the approach applied regarding the distribution of effort, see Section 5.2.

This option would remove the risk of a weakening of future targets by a more extensive use of this type of derogation. It would also lead to additional emission reduction from the potentially eligible manufacturers compared to option NIC 1[208].

Economic impacts

This option would contribute to remove the market distorting effects of the niche derogation and ensure a more level playing field among manufacturers.

Furthermore, half of the currently eligible eight niche manufacturers do not currently need the derogation and could comply with the "default" regime. For the remaining half, removing the possibility of a niche derogations may increase the cost of compliance. This could to some extent be compensated through the use of other current flexibilities such as pooling or eco-innovations. Half of the eligible manufacturers are members of pools as they belong to a group of connected manufacturers and all of them are connected to major manufacturer groups on the global market.

Administrative burden

Removing the niche derogation for car manufacturers would simplify the architecture of the Regulations and streamline the approach taken for cars and vans. It would reduce the number of derogation applications to be dealt with, which would slightly lower the overall administrative costs of the Regulation.

Social impacts

There are no direct or otherwise relevant social impacts of niche derogations.

[208] According to the 2015 and 2016 emissions monitoring data, 4 manufacturers out of the 5 having derogations would have missed their "default" specific emission target in those years.

6.7 Governance

6.7.1 Real-world emissions (RWG)

6.7.1.1 Change nothing (Option RWG 0)

A number of sources from the US[209,210] indicate that the combination of a laboratory based test procedure and market surveillance instruments can be to a certain extent sufficient to ensure a limited, constant and stable gap, i.e. of around 20% in that specific jurisdiction. It can be then accounted for when assessing the impact of specific target levels.

The introduction of the new WLTP test procedure as of September 2017 and of a revised type approval framework is expected to reduce significantly the gap currently observed in the EU. Although the new system has been carefully designed to this end, it is anticipated that a certain gap will remain as underlined in the opinion of the Scientific Advisory Mechanism[211].

The lead time required to address any remaining gap solely by extensive changes of the reference test procedure developed in the context of UNECE is expected to be long with respect of the timeframe of the proposed legislation.

6.7.1.2 Option RWG 1: Collection, publication, and monitoring of real world fuel consumption data

Environmental impact

A robust and regular monitoring and publication framework for real-world fuel consumption data will allow the verification of the assumptions made regarding the divergence between the test procedure values and the average real world emissions (see Section 6.1). Significant divergences can in turn trigger a review of the testing framework and where appropriate the CO_2 emission standards themselves. This policy option is therefore expected to have an important positive environmental impact.

The publication of real world fuel consumption data would contribute to raising public awareness of fuel economy measures and promote the market up-take of CO_2 reducing technologies. A co-benefit would therefore be secured through the resulting market effect and competition among manufacturers for vehicles and technologies delivering significant fuel savings on the road.

The environmental effectiveness of this policy option would be linked to the quality of the available data.

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. The real-world fuel consumption data can be sourced or estimated by different means.

---

[209] Midterm Evaluation of Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards for Model Years 2022-2025, EPA, CARB, NHTSA 2016

[210] Greene D.L. et al, How Do Motorists' Own Fuel Economy Estimates, How Do Motorists' Own Fuel Economy Estimates Compare with Official Government Ratings? A Statistical Analysis, Baker Reports 2015

[211] https://ec.europa.eu/research/sam/pdf/sam_co2_emissions_report.pdf

If the standardised 'fuel consumption measurement device' becomes mandatory in new cars 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.

Administrative burden

The administrative costs would depend on the set-up of the data retrieval and processing system. For example in case of Commission studies based on *ad hoc* periodic test campaigns, the administrative costs would be limited to the costs for carrying out the studies and to process, analyse and report the data.

Social impact

The impact is expected to be positive for consumers as this option will provide consumers with information on real world emissions and fuel consumption and allow them to assess how those values compare to the fuel consumption of their own vehicles.

6.7.2 Market surveillance (conformity of production, in service conformity) (MSU)

6.7.2.1 Option MSU 0 – no change

Environmental impact

The verification by manufacturers of the correctness of the monitoring data provided by Member States is an essential step in ensuring legal certainty for the manufacturers in the process of determining compliance with their specific CO_2 emission targets.

However, while the current approach may lead to the identification (and subsequent remediation) of unjustified deviations from the type approved CO_2 emissions of vehicles placed on the road, it is nevertheless mainly dependent on information provided by the manufacturers.

This creates a risk that divergences in the CO_2 data used for assessing compliance may go undetected. Where this happens it may reduce the effectiveness of the Regulations in ensuring that the reductions foreseen are actually achieved.

Economic impact
The verification by manufacturers of the CO_2 data is currently optional. In case of no verification by the manufacturer, the data is considered correct. Should the Commission be informed of errors, it may however proceed with further checks in conjunction with measures taken by Member States and may also to abstain from confirming a manufacturer's performance in meeting its targets as long as the data is not confirmed to be correct (this is the case with the Volkswagen pool data for 2014 and 2015).

Administrative burden

The administrative costs would depend on the set-up of the data retrieval and processing system. For example in case of Commission studies based on *ad hoc* periodic test campaigns, the administrative costs would be limited to the costs for carrying out the studies and to process, analyse and report the data.

Social impacts

The lack of an effective independent verification of the CO_2 data may result in deviations going undetected. This may in turn lead to less representative data on CO_2 emissions and fuel consumption being available to consumers.

6.7.2.2 Option MSU 1: Obligation to report deviations and the introduction of a correction mechanism

This option assumes a mechanism is in place to systematically and formally detect deviations from the type approval values as part of the conformity of production tests (type approval legislation on emissions testing) or during verification tests of vehicles in-service (to be established, e.g. as part of the type approval framework).

Environmental impacts

Obligations placed on national authorities to systematically report deviations to the Commission, and on the Commission to correct the CO_2 data should contribute to ensuring reliable and representative CO_2 data. This would contribute to improving the effectiveness of the Regulation by ensuring that the CO_2 reductions foreseen are actually achieved.

Economic impacts

The new requirement national authorities to report to the Commission any deviations found, regardless of whether they are detected as part of a formal type approval procedure or on the basis of independent verifications would allow the Commission to take further steps in ensuring that such deviations are penalised and remediated. This would avoid that such deviations undermine the CO_2 reduction objectives and hence the effectiveness of the regulations. It would also prevent the distorting effect such deviations may have on the competition among different manufacturers.

The reporting requirement combined with the possibility for the Commission to correct the average specific CO_2 emissions of a manufacturer in the case of serious and unjustified deviations from the type approval values would serve as a strong deterrent from placing vehicles on the market with deviating CO_2 and fuel consumption values. It could be expected that the mere possibility of being subject to such corrections would in itself reduce the risk for such deviations occurring systematically.

Administrative burden

The new reporting obligation would incur an administrative burden primarily on type approval authorities. They would have to make available to the Commission in a systematic manner any deviations found together with a report on the remedial measures imposed.

However, it can be assumed that this data has already to be documented and reported for the purpose of the type approval legislation. For manufacturers the administrative burden could slightly increase as there would be a stronger incentive to actively verify the monitoring data than is currently the case. It would require further assessment of the data by the Commission as well as follow-up of in terms of correction of the CO_2 data set.

Social impacts

An effective independent verification and correction regime should contribute to ensuring that consumers have access to reliable CO_2 and fuel consumption data.

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; efficiency concerns "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**

Table 55 summarizes the assessment of each option against these criteria, following the 5 categories of issues considered in the Impact Assessment.

The effectiveness of the policy options considers the extent to which the set objectives are achieved. As presented in Section 4, the objectives considered are the following.

General policy objective

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

Specific objectives

1. Contribute to the achievement of the EU's commitments under the **Paris Agreement** by reducing CO_2 emissions from cars and vans cost-effectively;
2. Reduce fuel consumption costs for **consumers**;
3. Strengthen the **competitiveness** of EU automotive industry and stimulate employment.

While CO_2 emission standards for cars and vans for the period post 2020 are a key element to achieve the above objectives, they cannot deliver on 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, national, and regional/city level. These include investment in the necessary refuelling/recharging infrastructure, investment in research, development and innovation for battery technologies (both current and next generation), policies supporting deployment through public procurement (Clean Vehicles Directive), policies supporting the internalisation of external costs linked to emissions (Eurovignette Directive), national incentive schemes and local level actions (see Section 1.1 for more details).

While for most of the issues a preferred option has been identified, as mentioned below, in the cases of the target levels and the LEV/ZEV incentives, trade-offs between the various options are described.

Table 55: Summary of key impacts expected

Key impacts expected				
✗✗	✗	*O*	✓	✓✓
Strongly negative	Weakly negative	No or negligible impact	Weakly positive	Strongly positive

1. EMISSION TARGETS				
METRIC				
Options considered	***Effectiveness***	***Efficiency***	***Coherence***	***Proportionality – added value***
Tank-to-Wheel (no change)	✓	✓	✓✓	✓✓
Well-to-Wheel	✓	✓	✗✗	✗✗
Embedded emissions	✓	✓	✗✗	✗✗
Mileage weighting	✓	✓	✓✓	✗✗
TIMING				
New CO_2 targets apply in 2030	✓	✗	✗	✓✓
New CO_2 targets apply in 2025 and in 2030	✓✓	✓✓	✓✓	✓✓
New CO_2 targets defined for each year 2022-2030	✓✓	✓	✓✓	✗
CO_2 TARGET LEVEL FOR CARS				
TLC20	✓	✓	O	✓✓
TLC25	✓✓	✓✓	✓✓	✓✓
TLC30	✓✓	✓✓	✓✓	✓✓
TLC40	✓✓	✓	✓	✓
TLC_EP40	✓✓	✓	✓	✓
TLC_EP50	✓✓	✗	O	✗
CO_2 TARGET LEVEL FOR VANS				
TLV20	✓	✓	O	✓✓
TLV25	✓	✓	✓	✓✓
TLV30	✓	✓✓	✓✓	✓✓
TLV40	✓✓	✓✓	✓✓	✓✓
TLV_EP40	✓✓	✓	✓	✓
TLV_EP50	✓✓	✓	✓	✓
2. DISTRIBUTION OF EFFORTS (cars and vans)				
No change: mass, current slope (DOE0)	O	✓	✗	✓
Mass, equal reduction effort for all (DOE1)	O	✓	O	✓
Footprint, equal reduction effort for all (DOE2)	✗	✓	O	O
No utility parameter, uniform target for all (DOE3)	✓	O	O	✗
No utility parameter, equal % reduction for all (DOE4)	✓	O	O	✗
3. ZEV / LEV INCENTIVES				
TYPE OF ZEV / LEV INCENTIVE – CARS				
No incentive	✗	O	O	O
Mandate	✓✓	✓	✓	✗
Crediting system (two way adjustment)	✓✓	✓✓	✓	✓
Crediting system (one way adjustment)	✗	✓	O	✓

Options considered	*Effectiveness*	*Efficiency*	*Coherence*	*Proportionality – added value*
TYPE OF ZEV / LEV INCENTIVE - VANS				
No incentive	×	O	O	O
Mandate	✓✓	×	✓	×
Crediting system (two way adjustment)	✓✓	×	✓	✓
Crediting system (one way adjustment)	×	×	O	✓
4. ELEMENTS FOR COST-EFFECTIVE IMPLEMENTATION				
ECO-INNOVATION				
Future review and possible cap adjustment	✓	✓	✓	✓
Extend scope to mobile air conditioning systems, incl. future review and cap adjustment	✓✓	✓✓	✓✓	✓
POOLING				
Enhanced pooling	O	✓	✓	✓
TRADING				
Trading	O	✓	✓	O
BANKING AND BORROWING				
Banking	O	✓	O	O
Banking and borrowing	×	✓	O	O
NICHE DEROGATION				
New derogation target for niche manufacturers	✓	O	✓	✓
Remove derogation for niche manufacturers	✓✓	O	✓✓	O
5. GOVERNANCE				
REAL-WORLD EMISSIONS				
Collection, publication and monitoring of real world fuel consumption data	✓✓	✓	✓	✓
MARKET SURVEILLANCE				
Obligation to report deviations and correction mechanism	✓✓	✓	✓	✓

7.1 Emission targets

7.1.1 Emission target - Metric

As described in Section 6 of this IA, the main distinction in the impacts of the different options for the metric of the CO_2 target lies in their coherence with other policies and in the additional complexity and administrative burden they might cause, compared to their added value.

The Tank-to-Wheel (TTW) approach, by focusing on reducing tailpipe CO_2 emissions from the light duty vehicle sector, is considered fully coherent with the other instruments contributing to the EU's climate and energy policy, including the EU ETS, the Effort Sharing Regulation, the fuels policy, including the proposal for a revised Renewable Energy Directive (RED II), as well as policy initiatives taken in the transport sector. The risk of double regulation will be minimised.

The same applies for the option of enhancing the TTW approach through mileage weighting. However, this would require establishing weighing factors for different vehicle categories and monitoring mileage over time, which would be costly and highly burdensome given the expected limited benefits in additional CO_2 emission reductions achieved.

As explained in Chapter 6, both a Well-to-Wheel (WTW) and embedded emissions metric would lead to double regulation, interfering with the EU ETS and/or EU fuels policy. Furthermore, a switch to a WTW or embedded emissions metric would lead to confusion in terms of responsibilities and liabilities, making vehicle manufacturers accountable for emissions occurring outside their sector. Such approaches also risks creating additional burden, in particular in terms of monitoring and reporting obligations.

The choice of the metric for the CO_2 targets would in principle not affect the effectiveness of the policy, in particular with regards to the achievement of the specific objective to reduce CO_2 emissions. However, different metrics may have different impacts on the sources and sectors of CO_2 emissions associated with vehicles, i.e. the vehicle itself during use, the fuel/electricity sector, or vehicle manufacturing.

Similarly, the options considered could in principle all be equally efficient as the costs and benefits will be largely determined by the target level and by how the efforts are distributed across the sectors concerned. However, they clearly differ in terms of the associated administrative costs.

The preferred option for the emission target metric is thus to maintain the Tank-to-Wheel (TTW) approach with targets set in g CO_2/km for the sales-weighted average of the fleet.

7.1.2 Emission targets – timing

The option with new targets applying in 2025 and in 2030 scores very high on all criteria. Setting CO_2 targets also in 2025 would provide a clear and early signal for the automotive sector to increase the market share of LEV/ZEV in the EU from the early 2020s on. It would incentivize the European automotive sector to swiftly upscale their investments in key technologies as batteries and benefit early on from the economies of scale and learning. As other jurisdictions – like China and California – are going forward with strong incentives for LEV/ZEV, there is a risk that – without a 2025 target – European automotive industry may fall behind and foreign competitors gain a cost advantage.

At the same time, it 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_2 emissions early. As a result, cumulative emission reductions are expected to be higher as described in Section 6. This option is also coherent with the broader climate and energy policy by ensuring that the cars/vans policy will contribute delivering on time on the annual objectives set in the broader context of the proposed effort sharing decision for 2030, while leaving flexibility for manufacturers as regards the trajectory to follow in the intermediate years.

Postponing the new CO_2 targets for cars and vans until 2030 causes the policy to be less effective in reducing CO_2 emissions. Given the long fleet renewal time, the introduction of more efficient vehicles only around 2030 would result in higher overall emissions from road transport emissions for many years thereafter.

This option is also less effective against the second specific objective as consumers would miss out on significant fuel savings in the period up to 2030. This would also increase the costs of the policy and in turn negatively influence its efficiency.

All of this makes this option not fully coherent with the broader climate and energy policy as the cars and vans CO_2 targets are one of the key elements contributing to achieving the 2030 climate and energy objectives.

The option of setting annual targets, while being highly effective in reducing CO_2 emissions and in steering the market uptake of more LEV and ZEV, would leave manufacturers very little flexibility during any year of the period. Compared to the limited added value it may bring, such an annual compliance requirement seems overly restrictive.

The preferred option is thus to set new CO_2 targets for cars and vans applying from 2025 and stricter targets applying from 2030 on.

7.1.3 Emission targets – level for cars

The options considered cover a range of target level trajectories up to 2030. As described in Section 6 of this IA, the stricter the target levels set, the higher their effectiveness in achieving the specific objective of reducing CO_2 emissions. The additional reductions in 2030 compared to 2005 on top of the baseline range from 4 percentage points (TLC20) to 11.4 percentage points (TLC_EP50). In 2040, the range is from 19.1 percentage point (TLC20) to 30.3 percentage points (TLC_EP50).

The co-benefits in terms of reduced air pollution also increase with the stringency of the target, leading to additional reductions of NO_x and $PM_{2.5}$ emissions by 2030 from 2020 compared to the baseline ranging from 2 percentage points (TLC20) to 8 percentage points for NOx and 10 percentage points for $PM_{2.5}$ (TLC_EP50).

Stricter targets will also increase the market uptake of LEV and ZEV accelerating innovation and reaching economies of scale. However, the change in the fleet composition will be rather gradual compared to the baseline. For instance, for a 30% reduction target, the share of gasoline and diesel cars in 2030 will still be almost three quarters of the total new feet compared to slightly more than 80% in the baseline. Only at the higher target levels, the change would be more rapid. For the most ambitious option considered, the gasoline and diesel car share would decline to a little more than 55%.

All options considered deliver benefits for consumers. The 'total cost of ownership' reflects the change in costs from an end-user perspective of an 'average new car'. As the fleet-wide target levels get higher, the capital costs increase as well as the fuel cost savings. Highest net savings for the total cost of ownership can be realised with a reduction target of 25% or 30%. For these options, the net savings for a 2030 'average new car' are about 1,400 EUR considering a lifetime of 15 years and around 800 EUR for the first user during the first 5 years after registration of the vehicle.

The net savings for the second user increase with the stringency of the targets and are higher than those for the first users, benefiting the lower income groups of consumers. The net savings for the second user are higher for a 30% reduction target than for the 25% option.

As regards the macro-economic impacts, the results show a very small positive impact for the policy scenarios compared to the baseline in terms of EU-28 GDP. It is projected that higher CO_2 targets trigger increased consumer expenditure as well as increased infrastructure investment. This combined impact, as well as a reduction in imports of petroleum products, would result in an overall positive impact on GDP and reduce the import dependency of the EU economy.

On the one hand, at the sectoral level, there would be an expansion of the automotive supply chain, which would translate into a production increase in sectors such as rubber and plastics, metals and electrical and machinery equipment. This reflects the impact of increased demand from the automotive sectors for batteries and electric motors.

On the other hand, the automotive sector itself would see a small decrease in value added due to the decreasing use of combustion engines in cars. Similarly, the power and hydrogen supply sectors would increase production reflecting increased demand for electricity and hydrogen to power electric vehicles, while the petroleum refining sector would see a lower production. With more stringent target levels, these effects would become slightly more pronounced.

With more ambitious CO_2 target levels resulting in an increase in economic output, there is also a marginal increase in the number of jobs across the EU-28 compared to the baseline. The number of additional jobs also increases slightly over time. The main drivers behind the GDP impacts also explain the employment impacts. The exact magnitude of the employment impacts will depend among others whether the battery production will take place in the EU or whether batteries will be imported from Asia. Additional enabling measures for EU investments into battery production would amplify the positive employment effects.

Shifts in sectoral economic activity will also affect the skills and qualifications required in the automotive sector. Given the gradual shift to electrified powertrains and the expected relatively high share of plug-in hybrid vehicles until 2030, there will be sufficient time for re-skilling and up-skilling.

In light of the analysis carried out, the target level of 20% scores less positively on effectiveness than 25% and 30% in particular in view of the CO_2 emission reduction and the lower deployment of ZEV/LEV and fuel efficient technologies. Higher target levels of 40% and above score less positively with regards to the net savings for consumers over 15 years and over the first 5 years. However, they lead to higher market uptake of ZEV/LEV and more net savings for the second owners.

Looking at the efficiency of the options from a societal perspective, the analysis shows that the highest net savings[212] can be realised at target levels of 25% and 30% in both years 2025 and 2030. However, when considering the CO_2 external costs, the 30% scenario provides higher benefits than 25%. The 50% scenario delivers no net savings, as the highest target levels lead to significantly higher manufacturing costs. The 40% and 50% also scores lower with regards to proportionality in view of the higher manufacturing costs.

In terms of coherence, a key consideration is related to the way the car CO_2 targets would deliver a cost-effective contribution to reducing emissions of the sectors covered by the Effort Sharing Regulation by 2030. In this respect, higher targets enhance the capabilities of Member States in meeting their target under the Effort Sharing Regulation, taking into account also that other sectors covered by this Regulation, such as agriculture and freight transport have a lower than average cost–effective emission reduction potential. However, the highest targets would score less positively against the coherence criteria in view of the increased manufacturing costs.

7.1.4 Emission targets – level for vans

Regarding the effectiveness and proportionality of the emission targets for vans, similar considerations apply as for cars. The higher the target levels set, the higher their effectiveness in achieving the specific objective of reducing CO_2 emissions and the co-benefits in terms of air quality. Higher targets will also increase the market uptake of LEV and ZEV accelerating innovation and reaching economies of scale. Similar conclusions can also be drawn up as regards the macro-economic impacts including on employment.

As regards the benefits for consumers, the highest net savings over 15 years and 5 years and for the second user occur in the case of the 40% reduction level.

In terms of efficiency, the highest net savings from a societal perspective are found for options TLV40 followed by TLV30.

In terms of coherence with the overall climate and energy policies, TLV30 and TLV40 are both scoring somewhat better than the other options given the emission reductions and societal net savings delivered.

7.2 Distribution of efforts (cars and vans)

The key specific objective considered to assess the effectiveness is to ensure a fair distribution of effort among the manufacturers, thus avoiding that competition is distorted, without undermining the overall emission reduction potential.

As described in Section 6, for cars, the first three options, which are based on a limit value curve, are comparatively less effective as they tend to lead to higher costs for manufacturers of smaller vehicles, both in absolute and in relative terms. This is especially the case for the footprint-based option.

For vans, the options based on footprint and with a uniform target result in significantly higher manufacturing cost increases for manufacturers of larger vehicles.

Another important element for the analysis is the consideration of the proportionality with regards to the flexibility left for manufacturers in adapting their future fleet

[212] The net savings observed are the result of differences in capital/manufacturing costs, fuel cost savings and operational & maintenance costs.

composition depending on consumer demand. For both cars and vans, the options DOE3 and DOE4 without a utility parameter leave less room for changes in the fleet composition, and may cause greater challenges for manufacturers producing a less diversified fleet of mainly larger or mainly smaller vehicle models.

As regards the proportionality, maintaining a mass based approach compared to footprint would be the simplest option from an administrative point of view. Changing the utility parameter would also create uncertainty for the future.

As regards the efficiency, as explained in Section 6.4, the overall cost is hardly affected by the approach chosen to distribute the EU-wide fleet target across manufacturers. However, the absence of a utility parameter would reduce the flexibility of manufacturers, creating risks to increase the costs of the policy.

As regards internal coherence, the approach of keeping the slopes of the limit value curve as currently established in the Cars and Vans Regulation could be questioned. These slopes were specifically linked to the currently applicable targets for 2020/2021. With the switch to WLTP and the new targets to be set for post-2020, there seems to be no sound basis for simply maintaining them. For the other options considered, no other issues regarding the internal or external coherence were noted.

The preferred option for distributing the EU-wide fleet targets across individual manufacturers from 2025 on, is to use a limit value curve, with the manufacturer specific targets depending on the average WLTP test mass of the vehicles. The slope of the curve should ensure an equivalent reduction effort amongst manufacturers.

7.3 ZEV / LEV incentives

7.3.1 ZEV / LEV incentives for cars

The automotive industry is crucial for Europe's prosperity and the EU is among the world's biggest producers of motor vehicles and demonstrates technological leadership in this sector.

However, competition is increasing and the global automotive sector is changing rapidly with a higher number of market players from outside the EU, new innovations in electrified powertrains, autonomous driving and connected vehicles.

In order to retain its global competitiveness and access to markets, the EU needs to react proactively with an ambitious but realistic and cost-effective regulatory framework. This will support technological development and influence regulatory development outside the EU. This is particular important in the area of zero- and low-emission vehicles.

In terms of future market growth for electric vehicles, analysts expect that the global stock could increase from around 2 million electric vehicles in 2016 to between 9 and 20 million by 2020 and could reach between 40 and 70 million electric vehicles by 2025.

These forecasts are also reflected in recent announcements by major EU car manufacturers intending to significantly increase the share of electrified powertrains in their portfolio to as much as 25% in 2025 for some of the largest manufacturers.

In 2016 China was by far the largest electric car market in the world with more than twice as many registrations as the US or the EU and with very dynamic growth rates. While the Chinese electric car market grew by more than 60% in 2016, the EU market grew by 6% only. In 2016, Chinese car manufacturers increased their share in global electric vehicles production from 40% in 2015 to 43%.

This strong position of the Chinese market and manufacturers is expected to continue. In order to even further strengthen its competitive edge, China adopted in 2017 mandatory quotas for "new energy" vehicles for all domestic and foreign car manufacturers that produce for and/or import to the Chinese market. In the US, California and nine other States have successfully established a regulatory instrument to enhance the uptake of LEV since the early 1990s.

In the light of this policy context, the Impact Assessment is considering several options to introduce incentives for zero- and low-emission vehicles.

- The first option is a binding mandate under which each manufacturer would have to include at least a specific share of LEV in its new vehicle fleet.

- The second option is a more flexible crediting system with a two-way CO_2 target adjustment, building on and improving the current super-credits system. A manufacturer exceeding a certain benchmark of LEV/ZEV in its fleet would be allowed to meet a less strict CO_2 target, hence relaxing the need for efficiency improvements in internal combustion engines. However, a manufacturer whose sales share of LEV/ZEV fleet is below the benchmark would have to meet a stricter fleet-wide CO_2 target, which limits the risk of undermining the overall CO_2 fleet-wide target. Section 6 carries out an analysis on the effects of the over and under-achievement of the ZEV/LEV benchmark on the efficiency improvement for conventional vehicles.

- The third option is a crediting system with a one-way CO_2 target adjustment where the CO_2 target will be relaxed if the benchmark is overachieved. Not meeting the benchmark would have no consequences, i.e. the benchmark would become voluntary.

For the LEV/ZEV mandate or benchmark levels, a range from 10 to 25% in 2025 and 15 to 35% in 2030 has been looked at, depending on the scope of the vehicles considered, only ZEV or including LEV. The selected ranges broadly mirror the recent announcements by many EU manufacturers as regards their expected LEV uptake for the coming decade.

Starting from a rather low base, the accelerated uptake of LEV is expected to yield significant economies of scale, hence bringing down vehicle costs and making LEV more attractive for consumers and stimulating investments in infrastructure. Analysts project that the faster the market will grow the faster vehicle costs could come down.

Design of incentives for low- and zero-emission vehicles

A binding mandate and a crediting system with a two-way CO_2 target adjustment score the highest with respect to effectiveness and coherence as they provide a clear regulatory signal for industry to invest in LEV. This would create a larger internal market leading to economies of scale, bringing the technology costs down at a faster pace, to the benefit of consumers, industrial competitiveness and triggering investments in the necessary infrastructure.

A clear regulatory signal on the future market size for LEV/ZEV will reduce the risk for all market participants – be it car manufacturers, providers of charging infrastructure, or consumers – and allow a faster uptake. A well-chosen regulatory signal on the future market size – that is in line with the expectations of the car manufacturers – will make all market participants more confident to invest into LEV/ZEV technologies and contribute to solve the "chicken-and-egg" problem between vehicle manufacturers and providers of charging infrastructure. Private and public providers of charging infrastructure will have a more credible signal on the future charging demand and can invest with less risk.

A crediting system with a one-way CO_2 target adjustment would not create a clear signal leaving market participants less certain about the future size of the LEV/ZEV market and therefore investment risks increase. In addition, this creates a higher risk of undermining the environmental integrity of the regulatory system.

As regards efficiency, the analysis in Section 6 shows that the introduction of LEV incentives leads to higher net economic savings from a societal perspective, with the mandate providing the highest net economic savings compared to a crediting system.

However, compared to a crediting system, a binding mandate reduces the flexibility for manufacturers to react to changes in relative costs between LEV/ZEV and conventional technologies. If e.g. battery costs decrease faster than expected, a crediting system offers stronger incentives to invest further in LEV/ZEVs and increase further the competitiveness of the European automotive industry in this technology. A pure binding mandate does not offer these flexibilities and scores therefore lower in terms of efficiency and proportionality.

While having the advantage of being more flexible, the effectiveness and efficiency of a crediting system will eventually depend on the level of the benchmark. In particular, if the benchmark value is set below the level that the market expects for the future LEV/ZEV market share, this may have negative and perverse effects on the overall effectiveness. Take e.g. the case that the benchmark would be set at a very low level that would be over-achieved in any case. Such a benchmark would provide no additional incentives for the deployment of ZEV/LEV and may even allow every manufacturer to generate such a high amount of credits with no further need to improve the efficiency of conventional engines. There would neither be incentives for innovation in low-emission nor in conventional technologies.

Section 6 has analysed different levels for the ZEV/LEV benchmark – based on the modelled LEV shares for the future and broadly mirroring the recent announcements made by several major European manufacturers. Three benchmark level options–have been analysed for ZEV only and for ZEV and LEV together:

Table 56: Overview of ZEV/LEV benchmark level options

	ZEV only		***ZEV and LEV together***	
	2025	**2030**	**2025**	**2030**
Levels of the benchmarks	10%	15%	15%	25%
	15%	20%	20%	30%
	20%	25%	25%	35%

The difference between the levels of benchmark is notable in terms of effectiveness and efficiency:

- A higher LEV incentive level determines a stronger market signal, incentivises more investment on LEV and increases their market uptake, hence is more effective.

- As shown in Section 6, a LEV incentive increases the net savings up to a certain level. The higher-level benchmark values, while being more effective, show moderately lower net savings than the lower-level benchmarks.

Interaction between the LEV/ZEV crediting system and the CO_2 fleet-wide reduction level

The CO_2 fleet-wide reduction level and the level of the ZEV/LEV benchmark in the case of the crediting system will also have an impact on the efficiency of the conventional vehicles. Setting a more ambitious LEV incentive increases the market uptake of LEV. As a consequence, in order to comply with the CO_2 fleet-wide target, lower efforts are required to improve the efficiency of the conventional vehicles. This means that there would be less innovation incentives for the conventional engines.

This will have to be taken into consideration as part of the wider industrial policy when deciding the trade-off between the level of the CO_2 fleet-wide target and the parameters of the LEV/ZEV incentives i.e. (1) level of the LEV/ZEV benchmark, (2) the ratio between the over/underachievement of the LEV/ZEV benchmark and the credits for the adjustment of the CO_2 fleet-wide target, and (3) the limits to the adjustment itself of the CO_2 fleet-wide target.

A balanced approach is needed to provide for an effective set of incentives that yields high benefits for consumers, competitiveness, and the environment.

Targeting low- or only zero-emission vehicles?

As regards the definition of the vehicles covered by the incentives, a definition based on LEV would incentivize a higher uptake of plug-in hybrid vehicles compared to a pure ZEV benchmark. Further hybridisation is an important stepping stone allowing a smooth transition towards electrified powertrains. Furthermore, the higher labour intensity of the production of plug-in hybrid vehicles compared to conventional vehicles and ZEV would keep employment in the car manufacturing sector.

Conclusions

The preferred option as regards the LEV/ZEV incentive mechanism for cars is a crediting system.

A well-designed crediting system can provide a strong and credible signal for the development of zero- and low-emission vehicles while maintaining some improvement of the efficiency of the conventional engines beyond the 2020/2021 baseline. It will support the competitiveness of the EU automotive industry across all technologies and to ensure that significant benefits for consumers and environment will be achieved.

Market participants – car manufacturers, infrastructure providers, and consumers – will invest with more confidence when there is more certainty about the future market size for LEV/ZEV. A strong and stable home market for LEV/ZEV will be a key support for the competitiveness of the European industry. It will allow the European industry to benefit from a fast learning curve and economies of scale. Such a strong and large home market will be particularly important in view of the regulatory incentives set in other key export markets (e.g. China, California).

7.3.2 ZEV/LEV incentives for vans

The results for vans are quite different than for passenger cars in terms of overall efficiency. Section 6 shows that for vans the option without specific ZEV/LEV incentives provides higher net economic savings than the other options. For the other assessment criteria, the same scoring applies as for cars.

The preferred option is thus not to establish an additional ZEV/LEV incentive mechanism for vans.

7.4 Elements supporting cost-effective implementation

7.4.1 Eco-innovations

Both options to further develop the eco-innovation scheme score positively on all criteria. The main distinction is in the effectiveness of the options.

Extending the scope to mobile air conditioning (MAC) systems – in addition to a future review and possible cap adjustments – would further increase the effectiveness of the policy since MAC systems have become standard equipment in practically all vehicles. They have a significant cost efficient CO_2 emission reduction potential but have so far not been taken into account for reaching the CO_2 target. Thus potential efficiency improvements have been neglected. The extension to MAC would provide an important incentive to improve the efficiency of this widely used technology. In addition, it would increase the technology options available to manufacturers to cost-effectively reduce CO_2 emissions, and thereby improve the overall efficiency of the policy.

The preferred option is thus to maintain the eco-innovation provisions, while extending the scope to mobile air conditioning and allowing for a revision of the 7 g/km cap.

7.4.2 Pooling

Enhanced pooling would increase the efficiency of the policy in that independent manufacturers would benefit from legal certainty on the possibility to form a pool. This would help independent manufacturers to reach their specific emissions target at lower costs. In terms of coherence it is assessed positively with respect to the single market because it ensures a level playing field among all manufacturers.

The preferred option is thus to maintain the pooling provisions, while clarifying how manufacturers may form open pools.

7.4.3 Trading

Trading – in addition to pooling – could slightly positively affect the policy in terms of efficiency. By providing additional flexibility to manufacturers it could reduce overall compliance costs and generate an additional potential revenue stream for progressive manufacturers. In terms of coherence it is also assessed positively because it ensures a level playing field among all manufacturers. However, where it has been introduced it had very limited take-up but setting it up and running it would still add a significant administrative burden.

The preferred option is thus not to introduce the possibility for trading of CO_2 credits.

7.4.4 Banking and borrowing

Banking only as well as banking and borrowing could potentially increase the efficiency by providing more flexibility and hence reducing overall compliance costs for manufacturers.

However, allowing for borrowing creates the risk that manufacturers may not be able to balance out a negative amount of credits. It also raises concerns of liability and environmental integrity in case a manufacturer that has been borrowing credits to be used in future compliance periods would stop its activities.

Both options also add some additional administrative burden especially by the necessity to adding quite complex design elements.

The preferred option is thus not to introduce the possibility for banking or borrowing of CO_2 credits.

7.4.5 Niche derogations for car manufacturers

Comparing the two options on derogations for niche manufacturers shows that removing the derogation scheme would have strong positive effects on effectiveness and coherence. It would help to better achieve the specific policy objectives because it would incentivise lower average specific emissions of the new car fleet of niche manufacturers instead of possibly weakening future targets by more extensive use of this type of derogation.

Coherence would be improved by removing a possibly market distorting element in the current Regulation. However, a new derogation target for niche manufacturers scores better with regards to proportionality as it would allow niche manufacturers to continue benefitting from a derogation and hence reduce their compliance costs.

The preferred option is thus to remove the possibility for car manufacturers to be granted a "niche" derogation.

7.4.6 Simplification (REFIT aspects)

Compared to the current Regulations, the abovementioned preferred policy options, including on the ZEV/LEV incentives mechanism, are not expected to significantly affect the administrative costs caused by the legislation. In addition, they are not increasing the complexity of the legal framework.

In line with the findings of the Evaluation study, no changes in the compliance regime or in the level of the excess emissions premium are foreseen.

Under the preferred options, a number of existing flexibilities, such as super-credits and the 'niche' derogation, would be removed. The regulatory system will continue to provide for flexibilities to meet the regulatory requirements. These are intended to lower the compliance cost and most of them are offered to the regulated entities on a voluntary basis.

Next to the ZEV/LEV incentives, where a crediting system would allow compliance checking to be limited to the CO_2 emissions target, the main new elements considered are the governance related aspects. The preferred options for these elements are aimed to tackle the main weakness of the current Regulations identified by the Evaluation study and to follow-up on the call for closing the real-world gap from the Scientific Advice Mechanism and the European Parliament. The details of how these mechanisms will operate in practice will have to be elaborated later, and care should be taken at that stage to limit any administrative burden or complexity.

7.5 Governance: real-world emissions – market surveillance

The collection, publication and monitoring of real world fuel consumption data as well as an obligation to report deviations linked to a correction mechanisms would strongly increase the effectiveness of the regulatory framework.

Real world fuel consumption data would allow the verification of the assumptions made on the gap between test procedure values and the average real world emissions. In case significant divergences are reported, corrective actions could be taken 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 car purchase decisions towards more efficient vehicles.

The obligation to report deviations detected through improved market surveillance would complement real world data reporting by ensuring that CO_2 emissions of vehicles, as type-approved, are correct or that these are swiftly corrected in case of deviations. Since type-approved CO_2 emission values are used for assessing CO_2 target compliance introducing such a verification and correction procedure is critical to ensure that the CO_2 emission reductions objectives are actually achieved.

Both options would help consumers to benefit from higher fuel cost savings and they would be coherent with the overall objectives of EU policies in other areas such as vehicle type-approval and consumer protection.

The preferred option is thus to establish an empowerment for the Commission to allow (i) the collection, publication and monitoring of real world fuel consumption data and creating an obligation to report deviations linked to a correction mechanisms and (ii) to correct reported CO_2 emission values in case of deviations detected through improved market surveillance.

8 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 would allow the Commission to assess the effectiveness of the legislation and, where appropriate, propose changes.

Under the existing Cars and Vans Regulations on CO_2 emission standards, an annual reporting and monitoring procedure has been established. In order to assess the compliance of manufacturers with their annual specific emissions targets, Member States report every year data for all newly registered cars and vans to the Commission. In addition to the type-approved CO_2 emission and mass values, a number of other relevant data entries are monitored, including fuel type and CO_2 emission savings from eco-innovations.

The Commission, supported by the European Environment Agency (EEA), publishes every year the monitoring data of the preceding calendar year including manufacturer specific CO_2 performance calculations. Manufacturers have the opportunity to notify errors in the provisional data, as submitted by Member States. This well-established monitoring system constitutes an important basis for monitoring the impacts of the legislation.

The legislation will be based on this well-established monitoring and compliance framework. No essential elements are changed in the current framework that would add complexity. It will therefore neither increase administrative costs for manufacturers and competent national authorities nor enforcement costs for the Commission. A crediting system would be integrated in the existing compliance mechanism by merely adding another step in the methodology for calculating the performance of individual manufacturers/pools. No additional monitoring or reporting is required.

Additional administrative costs are linked to the new governance framework, i.e. the collection, publication and monitoring of real world fuel consumption data as well as the obligation to report deviations and use these for correcting the emissions data. However, in light of the importance to ensure transparency to consumers and representativeness of monitored CO_2 emission values, these costs appear well justified.

8.1 Indicators

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

- Contribute to the achievement of the EU's commitments under the **Paris Agreement** by reducing CO_2 emissions from cars and vans cost-effectively:
    - The EU-wide fleet average CO_2 emissions measured at type approval will be monitored annually on the basis of the monitoring data against the target level set in the legislation.
    - The gap between the type-approved CO_2 emissions data and real world CO_2 emissions data will be monitored through the collection and publication of real world fuel consumption data as well as reporting of deviations from the type approved CO_2 emissions and corrections to the CO_2 emissions data as initially reported by Member States and corrected by manufacturers.
    - Cars and vans GHG emissions will be monitored through Member States' annual GHG emissions inventories.

- The costs of technologies used in the vehicles and the fuel savings will be monitored on the basis of data to be collected from manufacturers, suppliers and experts.
- The number and share of newly registered zero/low emission vehicles will be monitored through the annual monitoring data submitted by Member States against the benchmarks set in the legislation .

- Reduce fuel consumption costs for **consumers**:
  - Development in fuel cost savings will be monitored through the EU-wide fleet average emissions as well as the collection of real world fuel consumption data and in-service conformity checks, if available.
  - The number of zero/low-emission vehicle models available on the market and development of purchase costs over time will be monitored through publicly available databases.
- Strengthen the **competitiveness** of EU automotive industry and stimulate employment:
  - The level of innovation will be measured in terms of new patents by European car manufacturers related to zero/low-emission vehicles and fuel-efficient technologies through publicly available patents databases. Data will be compared to past performance, both in terms of absolute numbers and relative share against main competitors form other world regions.
  - In addition to innovation activity, the competitiveness of the automotive sector will be monitored in terms of global market share of European car manufacturers in terms of new vehicle sales on the basis of publicly available data including from car manufacturer associations.
  - The level of employment will be monitored on the basis of publicly available Eurostat statistics on sectoral employment data for the EU.

The methodology for an evaluation of the legislation will put particular emphasis in 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 regression analysis/empirical research.

8.2 Operational objectives

Based on the policy options, the following operational objectives have been identified:

Operational objectives	**Indicators**
Reach a specific CO_2 emissions target level by the target year(s)	Compliance of manufacturers with their specific emissions target in the target year(s)
Achieve a certain level of deployment of zero/low emission vehicles in a specific year	Share of zero/low emission vehicles in that year
Achieve actual CO_2 emissions reductions without an increase in the "emissions gap"	Divergence between real-world emissions and type-approved/reported CO_2 emissions data

	Deviation between in-service conformity results and type-approved/reported CO_2 emissions data

EUROPEAN
COMMISSION

Brussels, 8.11.2017
SWD(2017) 650 final

PART 2/2

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

ANNEXES

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council setting emission performance standards for new passenger cars and for new light commercial vehicles as part of the Union's integrated approach to reduce CO2 emissions from light-duty vehicles and amending Regulation (EC) No 715/2007 (recast)

{COM(2017) 676 final} - {SWD(2017) 651 final}

Table of contents

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 (2015/CLIMA/019) and the work on the impact assessment.

An inter-service steering group (ISG), chaired by the Secretariat-General, was set up in December 2015 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 six times between December 2015 and the end of September 2017, discussing the inception impact assessment, the questionnaire for and results of the public consultation, the outcome of the stakeholder workshops and 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 25 September 2017 and following the Board meeting on 11 October 2017 issued a positive opinion with reservations on 13 October 2017.

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

Main RSB considerations	Response
The report does not describe the key EU policy initiatives that complement this initiative. It leaves out what these other EU initiatives need to achieve for this initiative to succeed.	The policy context and links with other EU initiatives, including the upcoming initiative on heavy duty vehicles have been further elaborated in Section 1.1 of the report. The contribution of the initiative to the Effort Sharing Regulation objectives is described in Sections 6.2 and 6.3.2.4.3. The EU Action Plan for Alternative Fuel Infrastructure and other flanking measures, such as the Revision of the Clean Vehicles Directive which will be part of the second 2017 Mobility Package, will ensure that infrastructure and demand-side action is aligned with supply-side measures. Additional enabling measures can be put in place by Member States or local authorities, as acknowledged in Sections 2 and 7 of the report.
The report does not explain the bottlenecks to a higher consumer uptake of electric vehicles. The report is also unclear on whether the competitiveness challenge is	The main elements hampering the uptake of more efficient vehicles are the fact that consumers value upfront costs over lifetime costs and/or have other consumer preferences, and in the particular case of zero-emission vehicles, the 'range anxiety' and

technological leadership or protecting EU employment.	concerns over the resale value of the vehicle. This is further elaborated in Section 2.2 (drivers 1 and 2), with reference to several studies. The competitiveness challenge for EU industry has been expanded in Section 2.1.3, highlighting the risk of losing technological leadership, esp. in view of the expected growing global demand of low-emission vehicles, and the increased cost-competitiveness of batteries, and recent regulatory developments in particular in China. Creating an EU market for low-emission vehicles is an important enabler for enhancing economies of scale, cost reduction and technological leadership, which in turn can help EU manufacturers retain market shares in the global automotive market. The link with employment and skills requirements is further elaborated in Section 6.3.2.2.3.3.
The impact analysis does not show how technical CO_2 standards increase consumer uptake of low-emission vehicles and make the European car industry more competitive. It does not indicate the cost of the flanking policies underlying the positive outcome.	The legislation setting CO_2 standards is a regulatory measure acting on the supply side, requiring vehicle manufacturers to develop, market and promote more efficient vehicles, including zero- and low- emission vehicles, in order to comply with the standards. Better and more models offered to consumers will result in a higher market uptake which will in turn drive additional investments in the needed refuelling and recharging infrastructure, for instance at home and in offices. In addition, the Alternative Fuel Infrastructure Plan aims to support the deployment of charging infrastructure along the core TEN-T network by 2025, thereby reducing range anxiety among potential customers. Furthermore, CO_2 standards complemented by well-designed incentives for zero- and low-emission vehicles provide a clear and long-lasting market signal for the entire automotive value chain, and create certainty for manufacturers. This will create economies of scale lowering the costs of low-emission vehicles, thus further contributing to their market uptake. Lower costs of batteries enable larger capacity batteries to be built into cars, thereby increasing the range and reducing range anxiety among potential customers. This is described in Section 5.3.1 of the report. In terms of the costs of flanking measures, the investments needed for the deployment of the

	fuelling/charging infrastructure are the most significant ones. The macro-economic analysis presented in Section 6.5.4 of the report takes into account the need for investments to support the roll-out of the necessary infrastructure.
The report does not identify which key trade-offs are genuinely open for political decision.	Section 7 of the report indicates the preferred option for most of the elements considered. In the case of the CO_2 target levels and the ZEV/LEV incentives, the report describes the trade-offs, points to the most cost-effective options and provides the necessary analysis for a political decision to be taken.
The report does not assess the regulatory burden and the potential for simplification	Overall, most of the policy options considered are not expected to significantly alter the administrative costs compared to the current Regulations. The ZEV/LEV incentives mechanisms considered would not create additional administrative burden. The deletion of the derogation for niche manufacturers will reduce administrative burden. No changes in the compliance regime and in the level of fines are foreseen. The impacts of the options related to governance will depend on the concrete implementing measures. Information on the expected impacts in terms of administrative burden has been added in different parts of Section 6.

Further RSB considerations and adjustment requirements	**Response**
The narrative on the links between this initiative and competitiveness of the EU automotive industry should be developed substantially. The report should expand on how the initiative to accelerate change in car technologies relates to support for public transport to reduce emissions. It should indicate how important policy initiatives like the Alternative Fuels Infrastructure Directive and the EU battery alliance are for the effectiveness of standard setting.	The links between this initiative and competitiveness of EU automotive value chain are described in Sections 2.1 and 4. This initiative is part of the second 2017 Mobility Package which includes different flanking measures, in particular the EU Action Plan regarding Alternative Fuel Infrastructure, the revision of the Clean Vehicle Directive and a dedicated initiative on batteries. The combination of regulatory (CO_2 standards, Clean Vehicles Directive), financing (infrastructure) and industrial (batteries) measures provides a mutually reinforcing approach on the demand and supply side to address the identified problems. This is

	described in Section 1.1 of the report.
The report should detail what elements would help promote consumer uptake. It should also clarify what elements would trigger greater demand for low-emission vehicles, leading to scale economies in production. The report should make clear which assumptions are responsible for the respective modelling outcomes.	As explained above, consumer uptake will be stimulated as a result of an appropriate combination of CO_2 standards, LEV/ZEV incentives and demand-side measures, leading to economies of scale, a better market offer and the removal of currently existing market barriers. Further information on the modelling approach and assumptions has been added in Annex 4, where reference is made to more detailed descriptions which can be found in public literature.
The impact assessment should make clear what has to complement the setting of emission standards to turn technological leadership into job and export opportunities for Europe, and what this would cost. It should also consider the risks that these complementary measures are not realised, and how the Commission will take this into account.	The Commission will review the effectiveness of the legislation, including in terms of the competitiveness impacts. A mid-term review is foreseen, which will allow taking into account *i.a.* the uptake of zero- and low-emissions vehicles, the evolution of technology costs and the progress made in establishing the necessary recharging infrastructure.
The report should clearly present the trade-offs between CO_2 targets (environmental benefits), impacts on consumers, public finances and impacts on the competitiveness of the EU car producers.	Section 6 of the report shows the detailed impacts of the options considered in terms of CO_2 emission reduction, the costs for manufacturers, and the savings from a societal perspective and for first and second end-users. As regards public finances, the macro-economic assessment assumes revenue neutrality. Additional information on the impact on public finance has been added in Section 6.

1.3 Evidence

The Impact Assessment draws on evidence from the evaluation of Regulations 443/2009 and 510/2011 on CO_2 emissions from light-duty vehicles[1]. The evaluation study provided a comprehensive assessment and concluded that the Regulations were overall effective, efficient and still relevant.

For the quantitative assessment of the economic, social and environmental impacts, the Impact Assessment report builds on a range of scenarios developed for the PRIMES-TREMOVE model by ICCS-E3MLab. This analysis was complemented by applying other modelling tools, such as GEM-E3 and E3ME (for the macro-economic impacts) and the JRC DIONE model developed for assessing impacts at manufacturer (category) level (see Annex 4 for more details on the models used and other methodological considerations).

[1] http://ec.europa.eu/clima/policies/transport/vehicles/docs/evaluation_ldv_co2_regs_en.pdf

Monitoring data on greenhouse gas emissions and other characteristics of the new light-duty vehicle fleet was sourced from the annual monitoring data as reported by Member States and collected by the European Environment Agency (EEA) under Regulations 443/2009 and 510/2011 on CO_2 emissions from light-duty vehicles[2].

1.4 External expertise

Further information was gathered through several support studies commissioned from external contractors, in particular addressing the following issues:

- the available technologies that can be deployed in the relevant time period to reduce new LDV CO_2 emissions, as well as their effectiveness and cost;
- elements potentially impacting industrial competitiveness and employment;
- growing gap between test and real driving emissions and the factors contributing to this;
- the impact of different regulatory approaches, regulatory metrics and possible design elements (modalities);
- impacts on GHG and pollutant emissions.

These studies were mainly run between 2014 and 2017 and the main ones are listed below:

- Data gathering and analysis to assess the impact of mileage on the cost effectiveness of the LDV CO_2 Regulations
- Improvements to the definition of lifetime mileage of light duty vehicles
- Improving understanding of technology and costs for CO_2 reductions from cars and LCVs in the period to 2030 and development of cost curves [to be published]
- Review of in-use factors affecting the fuel consumption and CO_2 emissions of passenger cars
- Supporting analysis on real-world light duty vehicle CO_2 emissions
- Data gathering and analysis to improve the understanding of 2nd hand car and LDV markets and implications for the cost effectiveness and social equity of LDV CO_2 regulations
- Assessment of the Modalities for Light Duty Vehicle CO_2 Regulations Beyond 2020 [to be published]
- Assessing the impacts of selected options for regulating CO_2 emissions from new passenger cars and vans after 2020 [to be published]

[2] https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-12/#parentfieldname-title for cars and https://www.eea.europa.eu/data-and-maps/data/vans-8/#parent-fieldname-title for vans

2 ANNEX 2: STAKEHOLDER CONSULTATION

2.1 Introduction

Stakeholders' views have been an important element of input to the revision of Regulation (EC) No 443/2009[3] and Regulation (EU) No 510/2011[4]. 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 revision of the Regulations.

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

- Member States (national, regional authorities)
- Vehicle manufacturers
- Component and materials suppliers
- Energy suppliers
- Vehicle purchasers (private, businesses, fleet management companies)
- Drivers associations
- Environmental, transport and consumer NGOs
- Social partners

The Commission sought feedback from stakeholders through the following elements:

- a public on-line consultation (20 July 2016 until 28 October 2016)
- a stakeholder workshop (24 March 2017) to present the results of the public consultation;
- a stakeholder workshop dedicated to jobs and skills (26 June 2017);
- meetings with relevant industry associations representing car manufacturers, components and materials suppliers, fuel suppliers.
- bilateral meetings with Member State authorities, vehicle manufacturers, suppliers, social partners and NGOs;
- position papers submitted by stakeholders or Member States.

A detailed summary and the results of the public consultation and the stakeholder workshop on jobs and skills are presented below.

[3] Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles, OJ L 140, 5.6.2009, p. 1

[4] Regulation (EU) No 510/2011 of the European Parliament and of the Council of 11 May 2011 setting emission performance standards for new light commercial vehicles as part of the Union's integrated approach to reduce CO_2 emissions from light-duty vehicles, OJ L 145, 31.5.2011, p. 1

2.2 Public consultation

2.2.1 Process and quantitative results

An on-line public consultation was carried out between 20 July 2016 and 28 October 2016 on the EU Survey website[5]. The consultation was divided into two sections, the first of which asked questions of a general nature, including the need and objectives for EU action, while the second was of a more technical nature asking questions related to policy design and intended for a well-informed audience. Respondents were invited to choose whether to complete only the first or both sections. The key issues addressed reflect the key elements of the impact assessment as follows:

- The need and objectives for setting CO_2 emission targets for cars and vans after 2020
- Technology specific requirements
- Distribution of efforts between different actors
- Incentivising low- and zero-emission vehicles
- Modalities (eco-innovations and derogations)

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 205 replies in total. The greatest number of responses (82 or 40%) were received from individuals. Civil society organisations, professional organisations and private enterprises all responded in fairly similar numbers, with 33 (16%), 31 (15%) and 28 (14%) responses respectively. Civil society organisations mainly included environmental and/or transport NGOs as well as consumer organisations. Professional organisations comprised mainly national and EU level associations representing the automotive sector and the fuels sector. Similarly, private enterprises included car manufacturers, suppliers in the automotive sector and fuels companies. Eleven public authorities from seven different Member States submitted replies, most of which operating at regional or local level. 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	6	3%
Civil society organisation	33	16%
Individual / private person	82	40%
International organisation	4	2%
Private enterprise	28	14%
Professional organisation	31	15%
Public authority	11	5%
Other	10	5%

[5] https://ec.europa.eu/clima/consultations/articles/0030_en.

Total	205	100%

Most responses were submitted from stakeholders based in Belgium (34), followed by Germany (26), the Netherlands and Denmark (17 each), France (15) and Hungary (13). Responses were received from all Member States, except for Croatia, Cyprus, Estonia, Malta and Slovakia. Six responses were received from stakeholders that were based outside the EU: Japan (4), Norway (1), and 'global' (1).

A stakeholder event was organised on 24 March 2017 in Brussels to inform stakeholders on the results of the on-line public consultation and to allow them to provide further feedback. The feedback received at the workshop was generally in line with stakeholders' views as submitted in the public consultation.

2.2.2 The need and objectives for setting CO_2 emission targets for cars and vans in the EU after 2020

When asked to assess the **importance of setting CO_2 emission targets for new cars and light commercial vehicles** to reduce emissions and contribute to meeting the EU's overall climate goals, most respondents across all stakeholder groups thought CO_2 emission targets for new cars and light commercial vehicles were 'important' or 'very important'. However, while all environmental and transport NGOs, consumer organisations, component suppliers, energy suppliers and public authorities (except for one regional authority) considered it 'very important', most car manufacturers considered it 'important'. Two car manufacturers and one petroleum company considered it 'somewhat important'.

There were mixed views on **whether, without EU action, Member States would individually implement legislation**. Most stakeholders representing the automotive sector[6] considered it likely that Member States would do so, whereas most environmental NGOs and consumer organisations considered it unlikely. Most respondents considered it likely (or were neutral) that this would lead to market fragmentation and higher costs. Only six individuals and one environmental NGO and one private enterprise considered this unlikely.

Policy objectives

Concerning the main policy objectives for future LDV CO_2 legislation, the following objectives were considered most important by the respondents:

- Continuing to reduce CO_2 emissions from LDVs cost-effectively and in line with EU climate and energy goals;
- Promoting the market update of LEV/ ZEV;
- Contributing to reducing air pollution.

The more detailed analysis shows that **continuing to reduce CO_2 emissions from LDVs cost-effectively and in line with EU climate and energy goals** was considered important by all but four respondents.

Ensuring technology neutrality was considered important by most respondents from the automotive sector (except for two car manufacturers who considered this objective unimportant). All public authorities that responded to the question considered this objective

[6] Car manufacturers or associations representing the car manufacturing industry.

important. While one environmental NGO considered this important, most environmental and transport NGOs and consumer organisations considered technology neutrality unimportant.

Ensuring competitive neutrality between manufacturers was considered important (or neutral) by all but three respondents.

Preserving the competitiveness of EU automotive manufacturing was considered important by most professional associations and consumer organisations as well respondents from the EU automotive sector. One non-EU car manufacturer and some environmental and transport NGOs judged this objective as unimportant. Other environmental NGOs and non-European car manufacturers had a neutral position.

Ensuring that the legislation's impacts are socially equitable was considered important by all consumer organisations as well as most private enterprises.. Most environmental and transport NGOs and some professional organisations as well as public authorities were neutral on this objective.

The objective to **promote the uptake of low-emission and zero-emission vehicles** was considered important by most respondents while only three oil companies and one national car industry organisation considered it unimportant. Some car manufacturers and one car industry association, component suppliers as well as one public authority expressed a neutral position.

Contributing to reducing air pollution was considered important by almost all respondents.

Action to be taken

The respondents were asked about the form that action should take and the majority favoured **LDV CO_2 emissions targets at the EU level**. Among the stakeholder groups this action was the most preferred option by nearly all civil society organisations as well as by most public authorities that responded to this question. "Other" was the second most chosen option as preference which in many cases was also supporting a target at EU level but with some specific preference on timing or target level.

Target levels

The majority of respondents thought that targets should be **set at a higher rate of reduction** than under current regulations, only few stakeholders were in favour of a lower rate. Most environmental and transport NGOs and the majority of individual respondents were in favour of a higher rate of reduction than that required under the current Regulations. However, consumer organisations were mostly in favour of a **similar rate of reduction as required under the current Regulations**. Most public authorities were in favour of higher or similar reduction rates; none was in favour of lower reduction rates. A **reduction rate lower than that required under the current Regulations** was supported by the European car manufacturers association and individual car manufacturers, the European trade union representing workers in the manufacturing sector as well as some component suppliers.

Innovation and competitiveness

When asked about innovation and competitiveness, the majority of respondents thought that EU legislation to regulate CO_2 emissions would **increase the competitiveness of EU industry on the global market** or were neutral on that point. One national car industry association and stakeholders from the petroleum sector disagreed that it would enhance competitiveness. When asked whether EU legislation to regulate CO_2 emission for LDVs will increase the likelihood of the EU automotive industry **developing further CO_2 reducing**

technology for conventional engines only four national associations representing different stakeholder groups disagreed. When asked whether future EU CO_2 legislation for LDVs would increase the likelihood of the EU industry **developing technology for alternative powertrains**, all stakeholders agreed or were neutral.

Social impacts

When considering social impacts, all consumer organisations, most environmental NGOs as well as several public authorities were of the opinion that **LDV CO_2 legislation is likely to lead to benefits for lower income social groups and countries.** Trade unions and stakeholders representing the petroleum industry largely disagreed with this statement. Most representatives of the automotive sector were neutral on this point. Most respondents were in favour of considering **second hand LDV purchasers and cross-border trade in second hand vehicles** when assessing the social impacts of the legislation, very few were opposed.

Regulatory aspects

Regarding the scope of the future CO_2 legislation nearly all car manufacturers were opposed (or neutral) to **extending the scope to heavier vehicles (N2) or to include small light commercial vehicles.** Most consumer organisations, stakeholders from the petroleum industry and public authorities were in favour of extending the scope.

As to whether **cars and light commercial vehicles should be covered by the same Regulation** a majority of respondents was in favour, but there was no clear trend among stakeholder groups except for car manufacturers and many consumer organisations which were against such an approach. Most stakeholders, including all car manufacturers, did not agree that **manufacturers should be replaced by manufacturer groups** as the regulated entity.

When asked whether the **current Tank to Wheel (TTW) metric should be replaced by a Well to Wheel (WTW) metric**, all but one of the stakeholders representing the fuels industry as well as some component suppliers supported such a change. By contrast, consumer organisations, car manufacturers and stakeholders from the power sector were mostly in favour of keeping the current TTW metric. Public authorities had mixed views.

The majority of all stakeholder groups was against (or neutral) **changing the current approach based on CO_2 emissions to be replaced by an approach based on energy use**.

In response to the question whether **emissions occurring during manufacturing and at the time of disposal** should be included, most car manufacturers were against this approach, whereas other stakeholder groups had diverging views.

Across all stakeholder groups there was very strong support for the **Commission to explore which potential exists to further reduce the divergence between the test cycles and real world emissions**. Only representatives of car manufacturers and one component supplier were against.

Similarly, all stakeholder groups supported **additional driving tests to give values closer to real emissions** except for car manufacturers and one component supplier who opposed this idea. More specifically, many environmental and transport NGOs, car drivers associations and public authorities from one Member State called for the extension of real-driving emission (RDE) tests to include CO_2 emissions, often in combination with a not-to-exceed limit.

The **use of mass monitoring of fuel consumption in vehicles for monitoring purposes** was opposed by car manufacturers and a national car drivers association and some local authorities, whereas environmental and transport NGOs were largely in favour of this. Consumer organisations, the automotive supply industry as well as the majority of public authorities were neutral on this issue.

2.2.3 Technology specific requirements

When asked whether **manufacturers should be given the freedom to choose the mix of technologies and emission levels for their vehicles provided they meet the overall target set for them**, the majority of all stakeholder groups and citizens were in favour of providing manufacturers with that freedom. Among the respondents all research institutions, consumer organisations, car manufacturers and public authorities supported such an approach. A comparatively small number of respondents were against.

There were rather mixed views across stakeholder groups on whether **specific CO_2 targets for different fuel types or technologies** should be set. While all car manufacturers and the majority of all stakeholder groups were not in favour of such specific targets, some environmental NGOs, some component suppliers, one oil company, and two public authorities supported specific targets. Consumer organisations were neutral on that point.

The majority in all stakeholder groups were in favour of continuing **setting manufacturer's targets based on their sales weighted average registrations**. All car manufacturers and consumer organisations were in favour, whereas car drivers associations were neutral on that issue. Some environmental NGOs and all respondents representing specifically the biogas sector were against continuing with the current target-setting approach.

Stakeholder views were very mixed on the question whether **average mileage by fuel and vehicle segment should be taken into account when establishing targets** A number of environmental and transport NGOs, some research institutions, and all respondents from the petroleum sector were in favour of that option. By contrast, one NGO and the majority of car manufacturers were against this option. Most consumer organisations were neutral on that issue, whereas public authorities were equally split on this issue.

2.2.4 Distribution of efforts between different actors

Most car manufacturers and consumer organisations were in favour of using a **utility parameter to distribute the effort between different vehicle manufacturers** (as in the current legislation). Most of the other respondents across different stakeholder groups were neutral on this question. A relatively small number of respondents from different stakeholder groups were against the use of a utility parameter.

When asked which utility parameter should be used, the majority of respondents did therefore not provide answer. Among those that provided an answer, all consumer organisations, some environmental and transport NGOs as well as stakeholders from the petroleum sector supported **footprint as utility parameter**. Most car manufacturers supported **mass as utility parameter**. One car manufacturer commented that any utility parameter should not discriminate against light-weighting efforts. Two stakeholders (a professional organisation and a national public authority) suggested that the loading capacity could be used for light commercial vehicles as utility parameter.

2.2.5 Incentivising low- and zero-emission vehicles

A majority of stakeholders across all stakeholder groups thought there should be a **mechanism to encourage the deployment of low and zero emission vehicles** (LEVs/ZEVs) except for consumer organisations which were mostly neutral on whether and how LEVs/ZEVs should be incentivised. Only one trade union, the works council of a German car manufacturer, two oil companies and one public authority were against such a mechanism.

A **mandate to produce and sell a minimum proportion of LEVs/ZEVs** was opposed by car manufacturers but supported by most environmental and transport NGOs. When asked what kind of incentive should be introduced for LEVs/ZEVs, most environmental and transport NGOs were in favour of a flexible mandate that differentiates between LEVs and ZEVs and allows trading among manufacturers. Some car manufacturers were in favour of super credits, one manufacturer referred to the need for public support for charging infrastructure. Public authorities were split on this issue.

Concerning the **definition of LEVs/ZEVs**, the majority of respondents across stakeholder groups supported the use of CO_2 emission performance as criterion but this was opposed by two environmental NGOs and two stakeholders representing natural gas based transport modes. **Zero emission range (km)** as criterion to define LEVs/ZEVs was opposed by a majority across stakeholder groups, while individuals were more in favour of this criterion. Some respondents, mostly environmental and transport NGOs, proposed a specific criterion on how to define LEVs with thresholds ranging from 15g/km to 50g/km (in 2030). However, one research institution argued that 50g/km was likely too high as it would overly incentivise plug-in hybrid vehicles with a very low electric driving range and therefore proposed 30g/km. The European car manufacturers association argued that the 50g/km (NEDC) threshold as currently used for super-credits should be used to define LEVs.

2.2.6 Modalities (eco-innovations and derogations)

A majority of stakeholders across all stakeholder groups was in favour of taking account of CO_2 emission reduction arising from the deployment of technology which reduces emissions in normal driving but whose benefit is not shown in the normal test cycle . A few environmental NGOs and public authorities were however against such an approach. When asked more specifically on how **eco-innovations** should be considered in the future legislation, only few respondents provided an answer. Environmental and transport NGOs were in favour of continuing the current eco-innovation scheme but some of them argued for measuring eco-innovation savings during real-driving emission tests for CO_2. Some stakeholders, mainly representing the steel industry, argued that the eco-innovation scheme should be complemented with an LCA credit option. The European car manufacturers association argued for the revision of some of the thresholds currently set in the legislation and supported the introduction of a pre-defined list of off-cycle CO_2 reduction technologies as well as the inclusion of technologies that are affected by the driver's behaviour.

Concerning the current **derogation regime,** car manufacturers were broadly in support of its continuation. Most other stakeholders also supported the current derogation regime for small volume car **manufacturers (less than 10 000 registrations per year)**, although some environmental NGOs and public authorities were opposed. By contrast, a majority of environmental and transport NGOs as well as all consumer organisations were against the continuation of the current derogation regime for **niche manufacturers (10 000 to 300 000 car registrations per year)**. Most consumer organisations but also a trade union and a works council as well as some public authorities supported to base the derogation regime on **worldwide sales instead of EU sales**. There was no strong support to grant derogations for certain types of vehicles rather than for manufacturers.

2.3 Dedicated stakeholder event on jobs and skills

A stakeholder meeting dedicated on jobs and skills was organised on 26 June 2017. The objective of the meeting was to seek experts' and stakeholders' views to ensure that all aspects are well covered in the impact assessment. The meeting was structured in two panels followed by an open discussion to allow all participants to present their views. In the first panel authors of relevant studies presented the methodology and key conclusions of their analysis, whereas the second panel was composed of representatives of the main stakeholder groups (vehicle manufacturers, component and materials suppliers, trade union, environmental and transport NGO) allowing them to present their perspective.

The key messages of the meeting can be summarised as follows:

- Broad agreement that alternative powertrains will play an important role in the future. There is a need for new qualifications (upskilling) and also higher participation rates in light of the demographic changes.
- Taking a macroeconomic perspective, the uptake of alternative powertrains will help consumers to save money (around EUR 500 p.a.) which they will spend in other sectors which will in turn create employment due low employment intensity of the refinery industry (around 500,000 net employment effect for EU).
- The creation of a large EU EV market with the help of ambitious policies will ensure that alternative powertrains will be manufactured in the EU with net job increase in the EU instead of importing alternative powertrains from other world regions with lead markets already in place that attract the production of alternative powertrains.
- manufacturers are faced with several transformative challenges including digitalisation and alternative powertrains which all require major investments in the coming years and new skills.
- SMEs provide a significant part of the employment and are faced with particular challenges to adjust to the new market.
- Labour intensity of ICE compared to BEV (7:1) coupled with lower maintenance requirements for BEVs (1 million BEVs reduce number of employees in maintenance by 1000).
- It is important to allow the workforce to adapt to the new qualification needs and to make the transition socially fair, e.g. organise social dialogues and provide for necessary supporting instruments.
- Impacts may be very different for different regions in the EU, e.g. regional clusters focussing on ICE.

The meeting was attended by more than 70 stakeholders representing all relevant stakeholder groups.

2.4 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

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

- Vehicle Manufacturers
- Suppliers of components and materials from which vehicles are constructed
- Users of vehicles, both individuals and businesses
- Suppliers of fuels and energy suppliers
- Vehicle repair and maintenance businesses
- Workforce
- Other users of fuel and oil-related products (e.g. chemical industry, heating)
- Society at large

The below table 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. Section 6 of the Impact Assessment provides a more detailed analysis on cost and benefits for the different target groups.

Type of stakeholder	**Practical implications**
Vehicle Manufacturers	Investment needs / manufacturing costs CO_2 standards require vehicle manufacturers to reduce CO_2 emissions as a result of which they will have to introduce technical CO_2 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. Benefits Demand for low- and zero-emission CO_2 vehicles is expected to increase throughout the world as climate change and air quality policies develop and other jurisdictions introduce similar or even more ambitious standards. European automotive manufacturers have an opportunity to gain first mover advantage and the potential to sell advanced low CO_2 vehicles in other markets, i.e. the new regulatory framework will help them to retain or even increase their global market in particular in markets for ZEV/LEV with very dynamic growth rates. Cost / benefits Manufacturers and suppliers are expected to largely benefit from increased revenues from the increase sales of low- and zero-emission vehicles, with revenues being distributed among businesses involved in the manufacturing, marketing and sales of vehicles (including vehicle dealers). Benefits will largely outweigh cost.

Suppliers of components and materials from which vehicles are constructed	Investment costs / new technologies Suppliers of components and materials from which vehicles are constructed will be affected by changing demands on them. Component suppliers have a key role in researching and developing technologies and marketing them to vehicle manufacturers. Investment costs will not be evenly spread across the supply chain. In particular suppliers for conventional vehicle technologies will have to adapt. Manufacturers and suppliers will have to invest into higher production capacities and technology development. These suppliers will also have to invest in skilling their workforce. Benefits Requirements leading to the uptake of additional technologies or materials (e.g. aluminium, advanced construction materials) may create extra business activity for suppliers in these sectors. In particular suppliers for non-conventional vehicle technologies will largely benefit.
Users of vehicles, both individuals and businesses	Transport costs/prices The use of technology to reduce in-use GHG emissions has a cost which is expected to be passed on to the vehicle purchaser. The purchase cost for new more fuel-efficient vehicles, in particular zero/low emission vehicles, is expected to be higher compared to less fuel-efficient vehicles. Benefits Reducing the vehicle's CO_2 emissions will reduce the energy required and in turn increase fuel cost savings for vehicle users. Over the vehicles' lifetime, operational cost savings, including lower O&M costs for battery electric vehicles, will compensate the higher procurement costs.
Suppliers of fuels and energy suppliers	Adjustment costs Suppliers of fuels are affected by reduced energy demand leading to less utilisation of existing infrastructure. If demand shifts to vehicles supplied with alternative energy sources, this may potentially increase the need for other types of infrastructure and create new business opportunities and challenges for electricity supply companies and network operators. Investment needs Energy suppliers/grid operators will have to invest into grid expansion and innovative technologies (e.g. smart metering) to cope with increased demand from recharging of vehicles. Benefits There will be new business opportunities for (alternative) fuel suppliers and energy suppliers as a result of the increase in electricity demand from electric vehicles.

Vehicle repair and maintenance businesses	With the uptake of battery electric vehicles there will be lower demand for maintenance requirements which will negatively affect vehicle repair and maintenance businesses. On the other hand, the uptake of plug-in hybrid electric vehicles will increase the complexity of the vehicle technology and require at least the same vehicle repair and maintenance as conventional powertrains. Moreover, the repair and maintenance of plug-in hybrid electric vehicles will require additional skills to deal with the electric and electronic components.
Workforce	The production and maintenance of vehicles with an electrified powertrain will pose important 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.
Other users of fuel and oil-related products (e.g. chemical industry, heating)	<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.
Society at large	Citizens, especially those living in urban areas with high concentrations of pollutants, will benefit from better air quality and less associated health problems due to reduced air pollutant emissions, in particular when the uptake of zero-emission vehicles increases.

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, E3ME, GEM-E3, JRC DIONE. 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 ESR and EED proposals, and for the analytical work in the SWD of the Low Emission Mobility Strategy.

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 National Technical University of Athens[7], based on, but extending features of the open source TREMOVE model developed by the TREMOVE[8] modelling community. Part of the model (e.g. the utility nested tree) was built following the TREMOVE model[9]. 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[10] has been successfully peer reviewed[11], most recently in 2011[12]. 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 Effort Sharing Regulation, the review of the Energy Efficiency Directive, the recast of the Renewables Energy Directive and for the European strategy on low-emission mobility.

---

7 Source: http://www.e3mlab.National Technical University of Athens.gr/e3mlab/

8 Source: http://www.tmleuven.be/methode/tremove/home.htm

9 Several model enhancements were made compared to the standard TREMOVE model, as for example: for the number of vintages (allowing representation of the choice of second-hand cars); for the technology categories which include vehicle types using electricity from the grid and fuel cells. The model also incorporates additional fuel types, such as biofuels (when they differ from standard fossil fuel technologies), LPG and LNG. In addition, representation of infrastructure for refuelling and recharging are among the model refinements, influencing fuel choices. A major model enhancement concerns the inclusion of heterogeneity in the distance of stylised trips; the model considers that the trip distances follow a distribution function with different distances and frequencies. The inclusion of heterogeneity was found to be of significant influence in the choice of vehicle-fuels especially for vehicles-fuels with range limitations.

10 The model can be run either as a stand-alone tool (e.g. for the 2011 White Paper on Transport and for the 2016 Strategy on low-emission mobility) or fully integrated in the rest of the PRIMES energy systems model (e.g. for the Low Carbon Economy and Energy 2050 Roadmaps, for the 2030 policy framework for climate and energy, for the Effort Sharing Regulation, for the review of the Energy Efficiency Directive and for the recast of the Renewables Energy Directive). When coupled with PRIMES, interaction with the energy sector is taken into account in an iterative way.

11 Source: http://ec.europa.eu/clima/policies/strategies/analysis/models/docs/primes_model_2013-2014_en.pdf.

12 https://ec.europa.eu/energy/sites/ener/files/documents/sec_2011_1569_2.pdf

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_2 emission performance standards for new passenger cars and new light commercial vehicles.

PRIMES-TREMOVE[13] 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 car 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 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 (microeconomic foundation).

Regarding the purchasing of new vehicles, a menu of technology options is considered; for private cars, the available technology portfolio includes different car sizes and different powertrain technologies and fuel types. The choice of car type follows the approach of discrete choice modelling. A Weibull functional form is used to determine the frequency of choice of a certain car type. 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, range anxiety, density of the refueling/recharging infrastructure.

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 consumers have risk avert behaviours regarding new technologies when they are still in early stages of market

[13] Pelopidas Siskos, Pantelis Capros, Alessia DeVita (2015) CO_2 and energy efficiency car standards in the EU in the context of a decarbonisation strategy: A model-based policy assessment", Energy Policy, 84 (2015) 22–34.

deployment. Perception of risk usually concerns technical performance, maintenance costs and operation convenience. When market penetration exceeds a certain threshold, consumers 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 decision-making is also influenced by the availability of infrastructure and the range provided by each vehicle technology. For the analysis in this impact assessment, the availability of infrastructure is assumed: no specific restriction of infrastructure availability allows to determine for each policy scenario the requirements in terms of infrastructure needed to support the projected market penetration of vehicles. In order to represent in a more refined manner the true effects of the range limitations of some vehicle technologies, the trip categories represented into the model are assumed to follow a frequency distribution of trip distances. The model assumes that decision makers compare the range possibilities of each vehicle technology for all classes of trip types and trip distances and applies cost penalties in case of mismatches between range limitations. Because of range anxiety issues, based on the frequency distribution of trips existing in the model, certain consumer categories observe high penalties when selecting vehicles with range limitations. For such trip profiles, electric vehicles are not a viable option.

When a CO_2 target for new cars and vans is set, a representative seller is assumed to offer to the market a variety of vehicle types which on average have to respect the target. The average performance against the standard is endogenously calculated depending on consumer choice of vehicle types. The average performance of the new fleet has to be below the value of the CO_2 standard. Otherwise, the representative seller increases the prices of non-complying vehicle types (in the form of a penalty). This penalty factor is estimated endogenously and depends on the difference between the value of the standard and the performance of the particular vehicle type. This procedure is repeated until average performance of the new fleet is below the value of the standard.

The PRIMES-TREMOVE model has been updated to handle a mandate on LEV shares, meaning that all manufacturers need to achieve a specific share of their total vehicle sales via sales of LEVs. The mandate is formulated similarly to the already existing implementation of the regulations regarding the emissions standards for new vehicle sales.

In a similar way, energy efficiency performance standards for all road transport modes are integrated in the model, setting an efficiency constraint on new vehicle registrations.

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_x, PM, SO_x, 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 capital and operating costs presented in Chapter 6 of the Impact Assessment.

The suite consists of different modules, some of which developed specifically for the analysis in this Impact Assessment, such as:

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

The technology costs and CO_2 saving potentials developed during the project "Supporting Analysis on Improving Understanding of Technology and Costs for CO_2 Reductions from Cars and LCVs in the Period to 2030 and Development of Cost Curves"[14] were used as an input to the DIONE Cost Curve Model. Hundreds of cost curves were developed and used for the Impact Assessment, covering ten powertrains (SI, CI, SI HEV, CI HEV, SI PHEV, SI REEV, CI PHEV, CI REEV, BEV, FCEV), 7 vehicle segments (small, lower medium, upper medium and large car; small medium and large LCV), and 4 cost scenarios (high, medium, low and very low for batteries).

On the basis of the defined cost curves, the DIONE Cross-Optimization Module determines the optimal (i.e. cost minimizing) CO_2 and energy consumption reduction for each manufacturer category, powertrain and segment, given the relevant targets, fleet compositions and cost curves. As the cost curves have positive first and second derivatives, this is a mathematical problem with a unique solution that can be solved by a standard optimization algorithm. Outputs from the Cross-Optimization Module are optimal CO_2 (for conventional vehicles and PHEV, REEV) or energy consumption (for BEV, FCEV) reduction (xopt) per manufacturer category, segment and powertrain and the corresponding manufacturing costs (copt), which represent the capital costs shown in Chapter 6 of the Impact Assessment.

The DIONE Energy Cost Module is used to calculate Fuel and Energy costs. For each manufacturer category, powertrain and segment, the WLTP energy consumption (MJ/km) is derived from the CO_2 emission reduction (to comply with the targets) using specific energy conversion factors. The WLTP energy consumption figures are converted to real world energy consumption by multiplying for the real world over WLTP uplift factors for each powertrain and segment, in 2025 and 2030.

The fuel and energy cost per powertrain and segment is calculated taking into account the specific energy consumption, the vehicles mileage, the fuel costs. Vehicle mileages per segment and powertrain as well as mileage profiles over vehicle lifetime are based on PRIMES-TREMOVE. Costs of conventional fuels, and electricity and hydrogen (EUR/MJ) are aligned with PRIMES-TREMOVE. They are discounted and weighted by powertrain / segment activity over vehicle age, such that they can be used as multiplicators within the calculation.

In the DIONE TCO (total cost of ownership) and Payback Module, technology costs and operating costs are aggregated, discounted and weighted where appropriate, to calculate total costs of ownership from an end-user and societal perspective.

[14] https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/technology_results_web.xlsx

https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/technology_sources_web.xlsx

Table 2 shows the main assumptions made for the costs assessment by DIONE.

Table 2: Main assumptions made for the costs assessment by DIONE

Element	Sub-category	Assumption	Notes
Discount Rate, %	Societal	4%	This social discount rate is recommended for Impact Assessments in the Commission's Better Regulation guidelines[15].
	End user (cars)	11%	Consistent with the Reference Scenario 2016[16]
	End-user (LCVs)	9.5%	Consistent with the Reference Scenario 2016
Period/age, years	Lifetime	15	
	First end-user	0-5	
	Second end-user	6-10	
Capital costs		% sales weighted average from DIONE	Average marginal vehicle manufacturing costs (including manufacturer cateogory profit margins) calculated by DIONE for a given scenario.
Depreciation			Based on CE Delft et al. (2017)[17]
Mileage profile	Total, and by age profile		The overall mileage is distributed over the assumed lifetime of the vehicle in the analysis, according to an age-dependant mileage profile estimated based on PRIMES-TREMOVE
Mark-up factor	Cars	1.40	Used to convert total manufacturing costs to prices, including dealer margins, logistics and marketing costs and relevant taxes. Consistent with values used in previous IA analysis according to (TNO et al., 2011)[18], (AEA/TNO et al., 2009)[19].
	LCVs	1.11	

[15] See: http://ec.europa.eu/smart-regulation/guidelines/tool_54_en.htm

[16] http://ec.europa.eu/energy/en/data-analysis/energy-modelling

[17] CE Delft and TNO (2017) Assessment of the Modalities for LDV CO_2 Regulations beyond 2020 (report for the European Commission, DG CLIMA)

[18] TNO, AEA, CE Delft, Ökopol, TML, Ricardo and IHS Global Insight (2011) Support for the revision of Regulation (EC) No 443/2009 on CO_2 emissions from cars (report for the European Commission, DG CLIMA) - https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/cars/docs/study_car_2011_en.pdf

[19] AEA, TNO, CE Delft, Öko-Institut (2009) Assessment with respect to long term CO_2 emission targets for passenger cars and vans (report for the European Commission, DG CLIMA) - https://ec.europa.eu/clima/sites/clima/files/transport/vehicles/docs/2009_co2_car_vans_en.pdf

			The mark-up for LCVs excludes VAT, as the vast majority of new purchases of LCVs are by businesses, where VAT is not applicable.
O&M costs	By LDV segment, powertrain type.	% sales weighted average of updated O&M costs.	The calculation of the O&M costs is based on the assumptions made in PrimesTremove, which were used already for the Low Emission Mobility Strategy. These are based on the TRACCS project database and have been revised in light of new evidence with respect to the costs for electrified powertrain types. The O&M costs are subdivided into three main components: (1) annual insurance costs, (2) annual maintenance costs, (3) other ownership costs, mainly including fixed annual taxes. The maintenance and insurance costs comprise the largest shares of the overall total O&M costs. The O&M costs assumptions used are based on recent estimates for maintenance and insurance costs[20]. No assumption is made on the evolution of the O&M costs over time for a new vehicle of 2025 or 2030, due to lack of available quantitative data.
VAT % rate		20%	Used to convert O&M costs including tax, to values excluding tax for social perspective.

4.3 Macroeconomic models (E3ME and GEM-E3)

Two macroeconomic models have been used, representing two main different schools of economic thought. E3ME is a macro-econometric model, based on a post-Keynesian demand-driven non-optimisation non-equilibrium framework; GEM-E3 is a general equilibrium model that draws strongly on supply-driven neoclassical economic theory and optimising behaviour of rational economic agents who ensure that markets always clear[21]. GEM-E3 assumes that capital resources are optimally allocated in the economy (given existing tax "distortions"), and a policy intervention to increase investments in a particular sector (e.g. energy efficiency) is likely to take place at the expense of limiting capital availability, as a factor of production, for

[20] Sources: Aviva. (2017). Your car insurance price explained. Retrieved from Aviva: http://www.aviva.co.uk/car-insurance/your-car-price-explained/; FleetNews. (2015). Electric vehicles offer big SMR cost savings. Retrieved from FleetNews: http://www.fleetnews.co.uk/fleet-management/environment/electric-vehicles-offer-big-smr-cost-savings; UBS. (2017). Q-Series: UBS Evidence Lab Electric Car Teardown – Disruption Ahead? UBS Global Research. Retrieved from https://neo.ubs.com/shared/d1BwmpNZLi/

[21] Market clearance in GEM-E3 is achieved through the full adjustment of prices which allow supply to equal demand and thus a ‘general’ equilibrium is reached and maintained throughout the system.

other profitable sectors ("crowding out" effect). In other words, in GEM-E3, the total effect on the economy depends on the net effect of core offsetting factors, particularly between positive improved energy efficiency and economic expansion effects (Keynesian multiplier), on one hand, and negative economic effects stemming from crowding out, pressures on primary factor markets and competitiveness losses, on the other hand. A very detailed financial model has been added to GEM-E3 to represent the banking system, the bonds, the borrowing and lending mechanisms, projecting into the future interest rates of equilibrium both for public sector finance and for the private sector. This changes the dynamics of crowding out effects as opposed to standard CGE models without a banking sector. E3ME does not adhere to the 'general' equilibrium rule; instead demand and supply only partly adjust due to persistent market imperfections and resulting imbalances may remain a long-run feature of the economy. It also allows for the possibility of non-optimal allocation of capital, accounting for the existing spare capacity in the economy[22]. Therefore, the level of output, which is a function of the level of demand, may continue to be less than potential supply or a scenario in which demand increases can also see an increase in output.

While the macro-economic modelling takes into account the wider economic and employment effects for the different policy options for the CO_2 vans/cars regulation, it does not analyse trade balance effects (export/import of cars) as a result of changed competitiveness of individual manufacturers. This would require detailed knowledge on (1) the expertise, R&D capabilities and competitiveness of individual car manufacturers; (2) expected regulatory changes in third countries in a 2030 perspective[23].

4.3.1 E3ME

E3ME is a computer-based model of Europe's economies, linked to their energy systems and the environment. The model was originally developed through the European Commission's research framework programmes in the 1990s and is now widely used in collaboration with a range of European institutions for policy assessment, for forecasting and for research purposes.

The model is run by Cambridge Econometrics, and its detailed description is available at https://www.camecon.com/wp-content/uploads/2016/09/E3ME-Manual.pdf.

The economic structure of E3ME is based on the system of national accounts, as defined by ESA95 (European Commission, 1996). In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment and international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

The labour market is also covered in detail, with estimated sets of equations for labour demand, supply, wages and working hours. For the assessment of employment impacts across the different sectors, labour intensities (number of persons per unit of output) are based on Eurostat Structural Business Statistics (sbs_na_ind_r2). As a starting point, the labour intensity of battery manufacture (which is included in the electrical equipment manufacturing sector) at the EU28 level is around 3 jobs per €1 million output, compared to a labour

[22] The degree of adjustment between supply and demand and the resulting imbalances are derived from econometric evidence of historical non-optimal behaviour based on the extensive databases and time-series underpinning the E3ME macro-econometric model.

[23] In the analysis done with both the E3ME and with GEM-E3 models, there is no assumption made in terms of policy changes outside of Europe

intensity of around 5 jobs per €1 million output in the wider electrical equipment manufacturing sector. The labour intensity of the automotive sector (excluding the battery manufacturing) is about 3.5 jobs per €1 million output, reflecting a high labour intensity for manufacture of vehicle parts and engines (5 jobs per €1 million output) but lower labour intensity for the assembly of the vehicle itself (less than 2 jobs per €1 million output). The model also accounts for labour productivity improvements (i.e. the ratio of sectoral employment to gross output over the projection period), based on PRIMES projections for output by sector and CEDEFOP projections for employment by sector.

4.3.2 GEM-E3

The GEM-E3 model has been developed and is maintained by E3MLab/ICCS of National Technical University of Athens[24], JRC-IPTS[25] and others. It is documented in detail but the specific versions are private. A full description of the model is available at https://ec.europa.eu/jrc/en/gem-e3/model

The model has been used by E3MLab/ICCS to provide the macro assumptions for the Reference scenario and for the policy scenarios. It has also been used by JRC-IPTS to assess macroeconomic impacts of target setting based on GDP per capita.

The GEM-E3 model is a multi-regional, multi-sectoral, recursive dynamic computable general equilibrium (CGE) model which provides details on the macro-economy and its interaction with the environment and the energy system. It is an empirical, large scale model, written entirely in structural form. GEM-E3 allows for a consistent comparative analysis of policy scenarios since it ensures that in all scenarios, the economic system remains in general equilibrium. In addition it incorporates micro-economic mechanisms and institutional features within a consistent macro-economic framework and avoids the representation of behaviour in reduced form. The model is built on rigorous microeconomic foundations and is able to provide in a transparent way insights on the distributional aspects of long-term structural adjustments. The GEM-E3 model is extensively used as a tool of policy analysis and impact assessment. It is updated regularly using the latest revisions of the GTAP database and Eurostat statistics for the EU Member States.

The version of the GEM-E3 model used for this Impact assessment features a significantly enhanced representation of the transport sector. The enhanced model version is referred to as GEM-E3T. The model is detailed regarding the transport sectors, representing explicitly transport by mode, separating private from business transport services, and representing in detail fuel production and distribution including biofuels linked to production by agricultural sectors.

GEM-E3 formulates separately the supply or demand behaviour of the economic agents who are considered to optimise individually their objective while market derived prices guarantee global equilibrium, allowing the consistent evaluation of distributional effects of policies. It also considers explicitly the market clearing mechanism and the related price formation in the energy, environment and economy markets: prices are computed by the model as a result of supply and demand interactions in the markets and different market clearing mechanisms, in addition to perfect competition, are allowed.

24 http://www.e3mlab.National Technical University of Athens.gr/e3mlab/

25 https://ec.europa.eu/jrc/en/institutes/ipts

GEM-E3 has a detailed representation of the labour markets being able to project effects on employment. Labour intensities for 2015 were calculated by dividing the full time jobs by the value of production of each sector. The economic and employment data are from the Eurostat database. For 2015, the direct labour intensity for conventional vehicle is 3.6 person per million output (excluding the number of persons required to produce all the intermediate inputs, which are accounted for in the respective sectors), while for electric vehicles it is 2.8 person per million output (excluding the number of persons required to produce all the intermediate inputs, which are accounted for in the respective sectors). Labour intensity projections are based on the results of the GEM-E3 that includes sectoral production and employment by 5-year period until 2050.

4.4 Baseline scenario

4.4.1 Scenario design, consultation process and quality assurance

The Baseline scenario used in this impact assessment builds on the EU Reference scenario 2016 but additionally includes few policy measures adopted after its cut-off date (end of 2014) 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 MS (with a cut-off date end of 2014[26]). Therefore, the binding 2020 targets are assumed to be reached in the projection. This concerns greenhouse gas emission reduction targets as well as renewables targets, including renewables energy in transport. 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.

[26] 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.

The report "EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050"[27] describes the inputs and results in detail. In addition, its main messages are summarised in the impact assessments accompanying the Effort Sharing Regulation[28] and the revision of the Energy Efficiency Directive[29], and the analytical work accompanying the European strategy on low-emission mobility[30].

PRIMES-TREMOVE is one of the core models of the modelling framework used for developing the EU Reference scenario 2016 and has also been used for developing the Baseline scenario of this impact assessment. The model was calibrated on transport and energy data up to year 2013 from Eurostat and other sources.

4.4.2 Main assumptions of the Baseline scenario

The projections are based on a set of assumptions, including on population growth, macroeconomic and oil price developments, technology improvements, and policies.

Macroeconomic assumptions

The Baseline scenario uses the same macroeconomic assumptions as the EU Reference scenario 2016. The population projections draw on the European Population Projections (EUROPOP 2013) by Eurostat. The key drivers for demographic change are: higher life expectancy, convergence in the fertility rates across Member States in the long term, and inward migration. The EU28 population is expected to grow by 0.2% per year during 2010-2030 (0.1% for 2010-2050), to 516 million in 2030 (522 million by 2050). Elderly people, aged 65 or more, would account for 24% of the total population by 2030 (28% by 2050) as opposed to 18% today.

GDP projections mirror the joint work of DG ECFIN and the Economic Policy Committee, presented in the 2015 Ageing Report[31]. The average EU GDP growth rate is projected to remain relatively low at 1.2% per year for 2010-2020, down from 1.9% per year during 1995-2010. In the medium to long term, higher expected growth rates (1.4% per year for 2020-2030 and 1.5% per year for 2030-2050) are taking account of the catching up potential of countries with relatively low GDP per capita, assuming convergence to a total factor productivity growth rate of 1% in the long run.

Fossil fuel price assumptions

Oil prices used in the Baseline scenario are the same with those of the EU Reference scenario 2016. Following a gradual adjustment process with reduced investments in upstream productive capacities by non-OPEC[32] countries, the quota discipline is assumed to gradually improve among OPEC members and thus the oil price is projected to reach 87 $/barrel in 2020 (in year 2013-prices). Beyond 2020, as a result of persistent demand growth in non-

---

27 ICCS-E3MLab et al. (2016), EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050

28 SWD(2016) 247

29 SWD(2016) 405

30 SWD(2016) 244

31 European Commission/DG ECFIN (2014), The 2015 Ageing Report: Underlying Assumptions and Projection Methodologies, European Economy 8/2014.

32 OPEC stands for Organization of Petroleum Exporting Countries.

OECD countries driven by economic growth and the increasing number of passenger cars, oil price would rise to 113 $/barrel by 2030 and 130 $/barrel by 2050.

No specific sensitivities were prepared with respect to oil price developments. Still, it can be recalled that lower oil price assumptions tend to increase energy consumption and CO_2 emissions not covered by the ETS. The magnitude of the change would depend on the price elasticities and on the share of taxation, like excise duties, in consumer prices. For transport, the high share of excise duties in the consumer prices act as a limiting factor for the increase in energy consumption and CO_2 emissions.

Techno-economic assumptions

For all transport means, except for light duty vehicles (i.e. passenger cars and light commercial vehicles), the Baseline scenario uses the same technology costs assumptions as the EU Reference scenario 2016.

For light duty vehicles, the data for technology costs and emissions savings has been updated based on a recent study commissioned by DG CLIMA[33]. Battery costs for electric vehicles are assumed to go down to 205 euro/kWh by 2030 and 160 euro/kWh by 2050; further reductions in the cost of both spark ignition gasoline and compression ignition diesel are assumed to take place. Technology cost assumptions are based on extensive literature review, modelling and simulation, consultation with relevant stakeholders, and further assessment by the Joint Research Centre (JRC) of the European Commission.

Specific policy assumptions

The key policies included in the Baseline scenario, similarly to the EU Reference scenario 2016, are[34]:

- CO_2 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_2 standards for cars are assumed to be 95 gCO_2/km as of 2021 and for vans 147 gCO_2/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.
- 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).

---

33 Ricardo Energy and Environment (2016) Improving understanding of technology and costs for CO_2 reductions from cars and LCVs in the period to 2030 and development of cost curves (report for the European Commission, DG CLIMA)

34 For a comprehensive discussion see the Reference scenario report: “EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050”

- 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[35];
- 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_2 emissions ratio of approximately 1.21 for cars when comparing the sales-weighted fleet-wide average CO_2 emissions. WLTP to NEDC conversion factors are considered by individual vehicle segments, representing different vehicle and technology categories[36].
- 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.[37]
- 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[38] 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.

4.4.3 Summary of main results of the Baseline scenario

EU transport activity is expected to continue growing under current trends and adopted policies beyond 2015, albeit at a slower pace than in the past. Freight transport activity for inland modes is projected to increase by 36% between 2010 and 2030 (1.5% per year) and 60% for 2010-2050 (1.2% per year). Passenger traffic growth would be slightly lower than for freight at 23% by 2030 (1% per year) and 42% by 2050 (0.9% per year for 2010-2050). The

[35] Regulation (EU) 2017/352

[36] See Annex 4.6

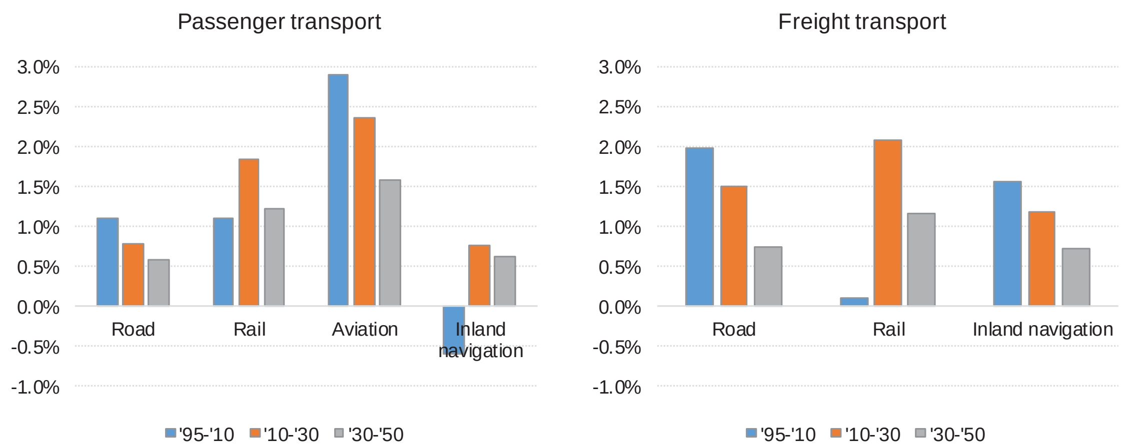
[37] Currently, 15,000 kilometres of federal trunk road and motorways are subject to tolls.

[38] E.g. http://www.viapass.be/fileadmin/viapass/documents/download/VlaanderenE.JPG

annual growth rates by mode, for passenger and freight transport, are provided in **Error! Reference source not found.**[39].

Road transport would maintain its dominant role within the EU. The share of road transport in inland freight is expected to slightly decrease at 70% by 2030 and 69% by 2050. The activity of heavy goods vehicles expressed in tonnes kilometres is projected to grow by 35% between 2010 and 2030 (56% for 2010-2050) in the Baseline scenario, while light goods vehicles activity would go up by 27% during 2010-2030 (50% for 2010-2050). For passenger transport, road modal share is projected to decrease by 4 percentage points by 2030 and by additional 3 percentage points by 2050. Passenger cars and vans would still contribute 70% of passenger traffic by 2030 and about two thirds by 2050, despite growing at lower pace (17% for 2010-2030 and 31% during 2010-2050) relative to other modes, due to slowdown in car ownership increase which is close to saturation levels in many EU15 Member States and shifts towards rail.

Figure 1: Passenger and freight transport projections (average growth rate per year)



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

Note: For aviation, domestic and international intra-EU activity is reported, to maintain the comparability with reported statistics.

Rail transport activity is projected to grow significantly faster than for road, driven in particular by the opening of the market for domestic passenger rail transport services and the effective implementation of the TEN-T guidelines, supported by the CEF funding, leading to the completion of the TEN-T core network by 2030 and of the comprehensive network by 2050. Passenger rail activity goes up by 44% between 2010 and 2030 (84% for 2010-2050), increasing its modal share by 1 percentage point by 2030 and an additional percentage point by 2050. Rail freight activity grows by 51% by 2030 and 90% during 2010-2050, resulting in 2 percentage points increase in modal share by 2030 and an additional percentage point by 2050.

Domestic and international intra-EU air transport would grow significantly (by 59% by 2030 and 118% by 2050) and increase its share in overall transport demand (by 3 percentage points

[39] Projections for international maritime and international extra-EU aviation are presented separately and not included in the total passenger and freight transport activity to preserve comparability with statistics for the historical period.

by 2030 and by additional 2 percentage points by 2050). Overall, aviation activity including international extra-EU flights is projected to go up by 60% by 2030 and 124% by 2050, saturating European skies and airports.

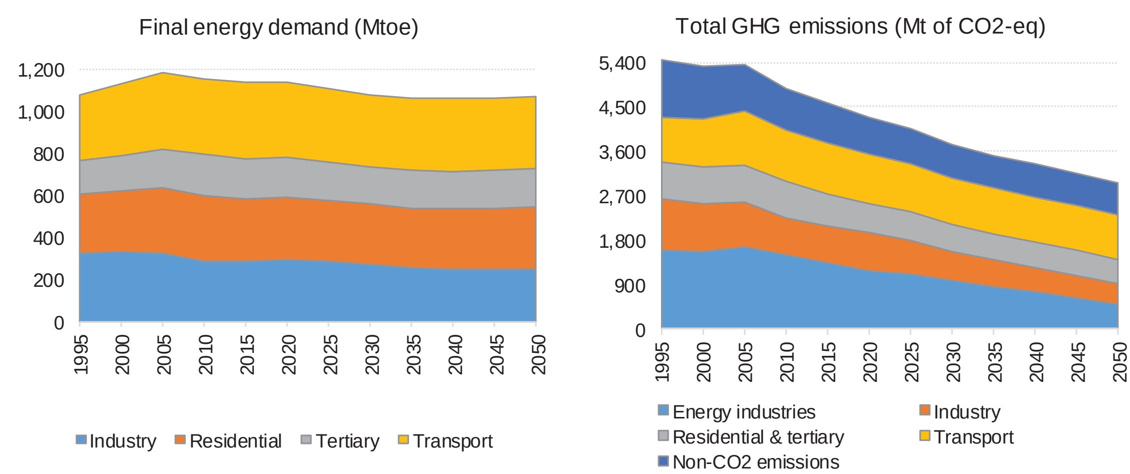
Transport activity of freight inland navigation[40] also benefits from the completion of the TEN-T core and comprehensive network, the promotion of inland waterway transport and the recovery in the economic activity and would grow by 26% by 2030 (1.2% per year) and by 46% during 2010-2050 (0.9% per year).

International maritime transport activity is projected to continue growing strongly with rising demand for oil, coal, steel and other primary resources – which would be more distantly sourced – increasing by 37% by 2030 and by 71% during 2010-2050.

Transport accounts today for about one third of final energy consumption. In the context of growing activity, energy use in transport is projected to decrease by 5% between 2010 and 2030 and to stabilise post-2030 (see Figure 2). These developments are mainly driven by the implementation of the Regulations setting emission performance standards for new light duty vehicles. Light duty vehicles are currently responsible for around 60% of total energy demand in transport but this share is projected to significantly decline over time, to 53% by 2030 and 49% by 2050. Energy use in passenger cars and passenger vans is projected to go down by 19% during 2010-2030 (-24% for 2010-2050). Heavy goods vehicles are projected to increase their share in final energy demand from 2010 onwards, continuing the historic trend from 1995. Energy demand by heavy goods vehicles would grow by 14% between 2010 and 2030 (23% for 2010-2050).

Bunker fuels for air and maritime transport are projected to increase significantly: by 17% by 2030 (33% for 2010-2050) and 24% by 2030 (42% for 2010-2050), respectively.

Figure 2: Evolution of total final energy consumption and GHG emissions for 1995-2050



Source: Baseline scenario, PRIMES model (ICCS-E3MLab)

Electricity use in transport is expected to increase steadily as a result of further rail electrification and the uptake of alternative powertrains in road transport. Battery electric and plug-in hybrid electric vehicles are expected to see faster growth beyond 2020, in particular in the segment of light duty vehicles, driven by EU and national policies offering various incentives and the decrease in battery costs. The share of battery electric and plug-in hybrid

[40] Inland navigation covers inland waterways and national maritime.

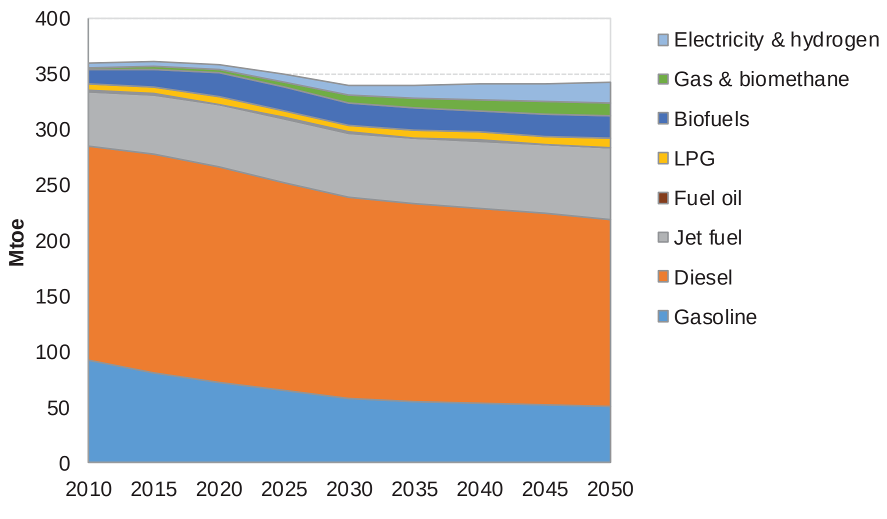
electric vehicles in the total light duty vehicle stock would reach about 6% by 2030 and 15% by 2050 (with the shares of battery electric being 2% in 2030 and 6% in 2050). The uptake of hydrogen would be facilitated by the increased availability of refuelling infrastructure, but its use would remain limited in lack of additional policies beyond those assumed in the Baseline scenario. Fuel cells would represent about 3% of the light duty vehicle stock by 2050.

LNG becomes a candidate energy carrier for road freight and waterborne transport, especially in the medium to long term, driven by the implementation of the Directive on the deployment of alternative fuels infrastructure and the revised TEN-T guidelines which represent important drivers for the higher penetration of alternative fuels in the transport mix. In the Baseline scenario, the share of LNG is projected to go up to 3% by 2030 (8% by 2050) for road freight and 4% by 2030 (7% by 2050) for inland navigation. LNG would provide about 4% of maritime bunker fuels by 2030 and 10% by 2050 – especially in the segment of short sea shipping.

Biofuels uptake is driven by the legally binding target of 10% renewable energy in transport (Renewables Directive), as amended by the ILUC Directive, and by the requirement for fuel suppliers to reduce the GHG intensity of road transport fuel by 6% (Fuel Quality Directive). Beyond 2020, biofuel levels would remain relatively stable at around 6% in the Baseline scenario. The Baseline scenario does not take into account the recent proposal by the Commission for a recast of the Renewables Energy Directive.

In the Baseline scenario, **oil products would still represent about 90% of the EU transport sector needs in 2030** and 85% in 2050, despite the renewables policies and the deployment of alternative fuels infrastructure which support some substitution effects towards biofuels, electricity, hydrogen and natural gas (see Figure 3.

Figure 3: Evolution of final energy use in transport by type of fuel



Source: Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

The **declining trend in transport emissions is expected to continue**, leading to 13% lower emissions by 2030 compared to 2005, and 15% by 2050.[41] However, relative to 1990 levels, emissions would still be 13% higher by 2030 and 10% by 2050, owing to the fast rise in the transport emissions during the 1990s. The share of transport in total GHG emissions would

[41] Including international aviation but excluding international maritime and other transportation.

continue increasing, going up from 23% currently (excluding international maritime) to 25% in 2030 and 31% in 2050, following a relatively lower decline of emissions from transport compared to power generation and other sectors (see Figure 2). Aviation would contribute an increasing share of transport emissions over time, increasing from 14% today to about 18% in 2030 and 21% in 2050. Maritime bunker fuel emissions are also projected to grow strongly, increasing by 22% during 2010-2030 (38% for 2010-2050).

CO_2 emissions from road freight transport (heavy goods and light goods vehicles) are projected to increase by 6% between 2010 and 2030 (11% for 2010-2050) in the Baseline scenario. For heavy goods vehicles, the increase would be somewhat higher (10% for 2010-2030 and 17% for 2010-2050), in lack of specific measures in place. At the same time, emissions from passenger cars and passenger vans are projected to decrease by 22% between 2010 and 2030 (32% for 2010-2050) thanks to the CO_2 standards in place and the uptake of electromobility. CO_2 emissions from buses and coaches are projected to remain relatively unchanged by 2030 compared to their 2010 levels, and to slightly increase post-2030 (3% increase for 2010-2050).

The overall trend in transport emissions is determined by three broad components: transport activity levels (expressed in passenger or tonne-kilometres), the energy intensity of transport (defined as energy consumption per passenger or tonne-kilometre) and the carbon intensity of the energy used (given by the CO_2 emissions divided by energy consumption). Following this approach, it has been evaluated how much the projected transport emissions will increase/decrease (in percentage terms or Mt of CO_2) between 2010 and 2030 due to transport activity growth, improvements in energy intensity and carbon intensity.[42,43]

Overall, CO_2 emissions from passenger transport decrease by 14% (109 Mt of CO_2) between 2010 and 2030 in the Baseline scenario. The 14% decrease in CO_2 emissions from passenger transport is due to transport activity growth (+21%, equivalent to 165 Mt of CO_2), improvements in energy intensity (-31%, equivalent to 246 Mt of CO_2) and in carbon intensity (-4%, equivalent to 28 Mt of CO_2). The trend for the three components and their contribution to emissions is different by transport mode. Efficiency gains play a decisive role in reducing emissions in road transport, while in aviation they would not offset the activity growth leading to higher fuel use and emissions. The use of less CO_2 intensive fuels contributes to a reduction of emissions for road and rail passenger transport with no effect on aviation by 2030.

For freight transport, the 5% (13 Mt of CO_2) increase in CO_2 emissions between 2010 and 2030 is the result of transport activity growth (+30%, equivalent to 75 Mt of CO_2), improvements in energy intensity (-20%, equivalent to 49 Mt of CO_2) and in carbon intensity (-5%, equivalent to 13 Mt of CO_2). The efficiency gains and the uptake of alternative fuels for road freight transport are not sufficient to offset the effects of activity growth, and thus CO_2 emissions go up between 2010 and 2030. The electrification in rail has positive effects on emissions, despite the growth in traffic volumes. For inland navigation, efficiency gains and to some lower extent the uptake of LNG has also positive effects on emissions reduction.

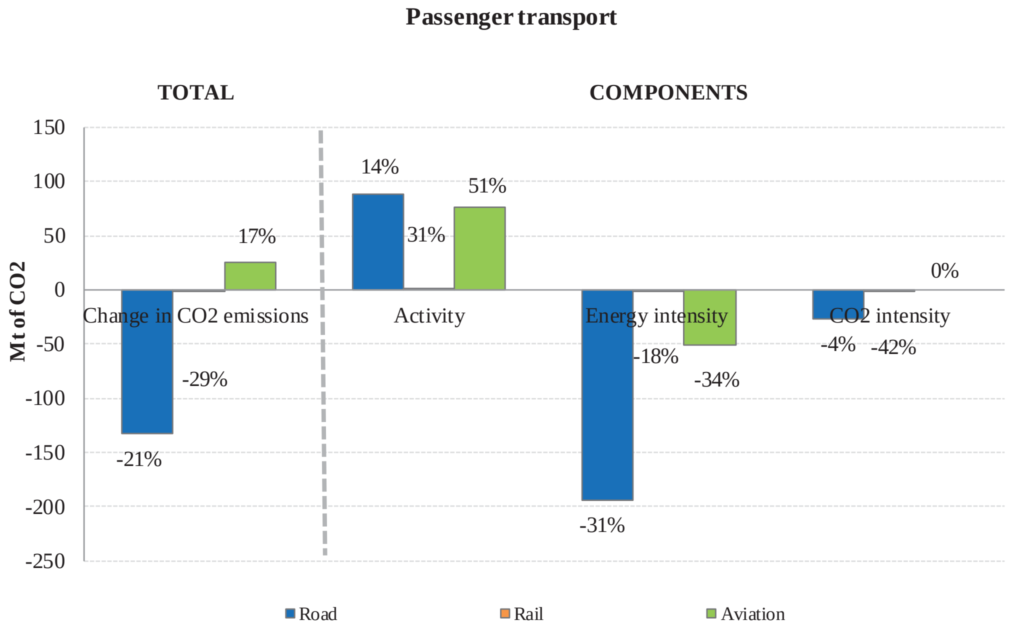
[42] The proposed method is the Montgomery decomposition. For a recent application of the method see: De Boer, P.M.C. (2008) Additive Structural Decomposition Analysis and Index Number Theory: An Empirical Application of the Montgomery Decomposition, Economic Systems Research, 20(1), pp. 97-109.

[43] The decomposition analysis only takes into account the tank to wheel emissions, under the assumption that biofuels are carbon neutral.

NOx emissions would drop by about 56% by 2030 (64% by 2050) with respect to 2010 levels. The decline in **particulate matter** (PM2.5) would be less pronounced by 2030 at 51% (65% by 2050). By 2030, over 75% of heavy goods vehicle stock is projected to be Euro VI in the Baseline scenario and more than 80% of the passenger cars stock is projected to be Euro 6. Overall, external costs related to air pollutants would decrease by about 56% by 2030 (65% by 2050).[44]

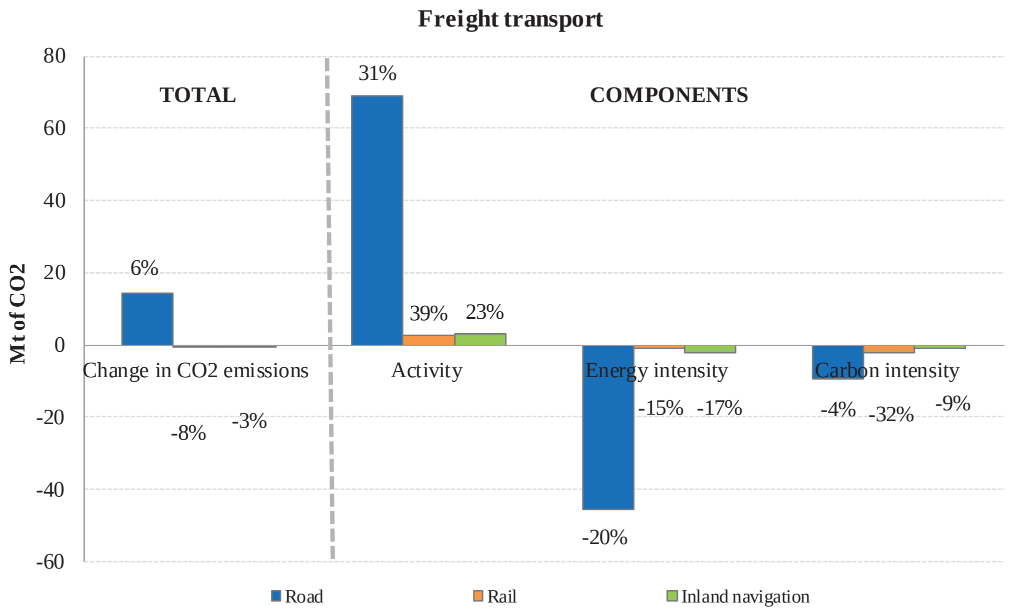
Noise related external costs of transport would continue to increase, by about 17% during 2010-2030 (24% for 2010-2050), driven by the rise in traffic. Thanks to policies in place, external **costs of accidents** are projected to go down by about 46% by 2030 (-42% for 2010-2050) – but still remain high at over €100 billion in 2050. Overall, external costs[45] are projected to decrease by about 10% by 2030 and to increase post-2030; by 2050 they stabilise around levels observed in 2010.

Figure 4: Decomposition of CO_2 emissions in the Baseline scenario (2010-2030)



44 External costs are expressed in 2013 prices. They cover NOx, PM2.5 and SOx emissions.

45 External costs cover here air pollution, congestion, noise and accidents.



Source: EC elaboration based on the Baseline scenario, PRIMES-TREMOVE transport model (ICCS-E3MLab)

Note: The figures report the changes in CO_2 emissions due to the three broad components (transport activity levels, energy intensity of transport and carbon intensity of the energy used) in two ways: in levels and in relative terms compared to 2010. The size of each column bar, read on the left axis, represents the change in terms of CO_2 emissions compared to 2010, expressed in Mt of CO_2. The percentage changes reported above the column bars represent relative changes in these emissions compared to their respective 2010 levels. Provided that CO_2 levels for 2010 corresponding to each transport mode are not comparable in size, the percentage changes reported in the figures are not directly comparable. The figures above include only tank to wheel emissions.

4.5 Consistency with previous analytical work

A consistency check was performed between the policy scenarios used for this impact assessment and the "*EUCO30*" scenario[46], which is underlying several Commission climate, energy and transport policy proposals adopted in 2016. This scenario corresponds in particular with the achievement of the EU-wide 2030 targets regarding greenhouse gas emissions in the ESR sectors and regarding final energy demand.

In addition to the LDV related policies, a number of broader, transport and fuel related policies[47] were accounted for in order to allow a direct comparison of the results.

The tables below show a comparison between the *EUCO30* scenario, and a scenario where the fleet wide targets for cars and vans are set at the levels of TLC30 and TLV25 (referred to as TL30c/25v).[48]

As the TL30c/25v scenario used for this impact assessment focuses on the LDV related policies, of the aforementioned broader, transport and fuel related policies[47] had to be accounted for in order to allow a direct comparison of the PRIMES-TREMOVE outputs with those of *EUCO30.* This is what is referred to below as the " TL30c/25v+" scenario.

Table 3 provides a comparison of emissions from the sectors covered by the ESR for those scenarios, under the assumption that changes in emissions only occur in the transport sector (emission levels remaining the same in all other ESR sectors).

Table 3: Comparison of ESR emissions (Mt CO_2) across scenarios

	2005	2030		
		EUCO30	TL30c/25v	TL30c/25v+
ESR emissions [Mt CO_2]	2,848	1,985	2,014	1,999
% change from 2005		-30.3%	-29.3%	-29.8%

In *EUCO30*, ESR emissions fall by 30.3% in 2030 compared to 2005 levels, which is in line with the 30% target. In the new TL30c/25v scenario, this reduction becomes 29.3% and, after including all *EUCO30* transport related policies and taking account of the Renewable Energy Directive revision (TL30c/25v+), reductions are 29.8%.

[46] The *EUCO30* scenario is a key input to several Commission documents adopted in 2016: Impact Assessment underpinning the Proposal for the Effort Sharing Regulation, Staff Working Document accompanying the Communication on the low-emission mobility strategy, Impact Assessment accompanying the proposal for recast of the Directive on the promotion of energy from renewable sources, Impact Assessment accompanying the proposal for a revised Energy Efficiency Directive. (https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf)

[47] These concern eco-driving, Cooperative Intelligent Transport Systems (C-ITS), internalisation of transport externalities, road infrastructure charges for Heavy Goods Vehicles. Concerning fuel policies, the TLC30c/25v and the *EUCO30* scenario assume that the 27% target for renewable energy in 2030 is met; scenario TLC30c/25v+ assumes in addition that the specific shares for renewable energy sources used in transport set in Article 7 of the Renewable Energy Directive Proposal for post 2020 are also met ..

[48] For the comparison with the *EUCO30* scenario, the scenario was chosen for which the CO_2 targets for the new fleet are consistent with those applied for *EUCO30*.

As shown in Table 4, the difference between *EUCO30* and the new policy scenarios is solely due to road transport, where CO_2 emissions in 2030 are 29 Mt higher under the TL30c/25v and 14 Mt under the TL30c/25v+ scenario.

Table 4: Comparison of transport emissions between *EUCO30* and new TL30c/25v scenarios in 2030 (Mt CO_2)

	2030 emissions			Difference between	
	EUCO30	TL30c/25v	TL30c/25v+	TL30c/25v and *EUCO30*	TL30c/25v+ and *EUCO30*
Transport total	871	900	885	29	14
Road transport	674	703	687	29	13
Cars	346	375	368	29	22
Vans	91	88	86	-3	-5
Other road transport	237	240	233	3	-4

Another consistency check with *EUCO30* concerns the Energy Efficiency target (30%)[49] for 2030. The difference in final energy demand in transport between the TL30c/25v, TL30c/25v+ and *EUCO30* in 2030 is 8 ktoe and 5 ktoe, respectively (Table 5). As these differences are very small compared to the "Gross Inland Consumption (GIC) of energy (minus non-energy uses)", it can be concluded that the energy efficiency target is also respected under the new policy scenarios.

Table 5: Final energy demand in EU-28 (ktoe)

	2007	2030		
	baseline	*EUCO30*	TL30c/25v	TL30c/25v+
Final energy demand in transport [ktoe]		322	329	326
Difference with *EUCO30*		-	8	5
GIC for energy	1,887	1,321 (-30.0%)	1,329 (-29.6%)	1,326 (-29.7%)

Table 6 shows a comparison for road transport based on the changes of emission reduction and final energy savings with respect to *EUCO30*.

Table 6: Greenhouse gas savings from 30% reduction in CO_2 standards for cars

Scenario	**Emissions savings 2005-2030**	**Lower emission savings in 2030**	**Higher final energy demand**
EUCO30	**24.7%**		

49 30% primary energy consumption reduction (i.e. achieving 1321 Mtoe in 2030) compared to the 2007 baseline (1887 Mtoe in 2030). This means a reduction of primary energy consumption of 23% compared to 2005 (1713 Mtoe in 2005).

TL30c/25v	**21.3%**	-3.4%	+3.2%
TL30c/25v+	**23.0%**	-1.7%	+2.1%

4.6 Determination of conversion factors from NEDC to WLTP emission values

JRC Science for Policy Report "From NEDC to WLTP: effect on the type-approval CO_2 emissions of light-duty vehicles" (*Tsiakmakis, S. Fontaras, G., Cubito, C., Anagnostopoulos, K., J. Pavlovic, Ciuffo, B.* (2017), publication pending)

EXECUTIVE SUMMARY

This study aimed at analysing the impact on the European light duty vehicle fleet CO_2 emissions of the introduction of the Worldwide Light duty vehicle Test Procedure (WLTP) in the European vehicle type-approval process. The calculations made for conventional vehicles rely mainly on the use of the PyCSIS (Passenger Car fleet emissions SImulator) model, which was developed on the basis of CO_2MPAS (CO_2 Model for PAssenger and commercial vehicles Simulation), the model used in the phasing-in of the WLTP for the adaptation of the CO_2 targets for light duty vehicles to the new test procedure[50]. However, while CO_2MPAS depends on the test results of individual vehicles, PyCSIS makes use of limited information, referring mainly to already available data sources and using empirical models and information collected from measurements at the Joint Research Centre of the European Commission.

The methodology was applied to assess the impact of the introduction of the new CO_2 certification procedure in Europe on the vehicle fleet CO_2 emissions.

Table 7 summarises the main results of this calculation for passenger cars and light commercial vehicles. For conventional, internal combustion engine (ICEV) passenger cars, the PyCSIS model has been applied to all new registrations of year 2015. For battery electric, plug-in hybrid electric and hybrid electric vehicles, a different approach has been used due to the limited number of such vehicles sold in the European market in 2015. For this reason, in the table below only the WLTP to NEDC ratio is shown or these vehicle segments and not the NEDC values.

Considering the certification values for CO_2 emissions, results for ICEV passenger cars show an average WLTP to NEDC CO_2 emissions ratio of 1.21 (sales weighted average across the fleet). The ratio is higher for cars with lower NEDC emission values, while at very high emission levels (about 250 CO_2 g/km) WLTP and NEDC lead to comparable results between the two procedures. Similar trends are found for light commercial vehicles, with a slightly higher average ratio for ICEVs (~1.3).

Results for hybrid electric vehicles (HEVs) show an average WLTP to NEDC CO_2 emissions ratio significantly higher than for ICEVs (approximately 1.33 for passenger cars and 1.4 for light commercial vehicles). Like in the case of ICEVs, the ratio is higher for vehicles with lower CO_2 emissions.

Results for battery electric (BEV) and fuel cell vehicles (FCEV) show an expected average WLTP to NEDC electric energy ratio of approximately 1.28 and a pure electric range ratio of approximately 0.9 (approximately 0.8 for BEV and 0.95 for FCEV). Differently from the case

[50] European Commission Regulations 1152/2017 and 1153/2017

of the ICEVs, the ratio for EVs remains approximately constant for vehicles of different size. In addition, the energy ratio is slightly higher for bigger vehicles than for smaller vehicles.

Table 7: Overview of the ratio between WLTP and NEDC emission levels for different types of passenger cars and vans

Passenger Cars		**NEDC Type Approval Emissions (g/km) (official 2015 data)**	**Ratio WLTP/NEDC**
All ICEV		123	1.21
Gasoline	**All**	125	1.22
	< 1.4 l	115	1.24
	1.4-2.0 l	148	1.15
	> 2.0 l	225	1.07
Diesel	**All**	121	1.20
	< 1.4 l	93	1.26
	1.4-2.0 l	114	1.21
	> 2.0 l	159	1.14
LPG		116	1.16
Gas		104	1.36
HEV Gasolinel	**< 1.4 l**		1.37
	1.4-2.0 l		1.32
	> 2.0 l		1.23
HEV Diesel	**< 1.4 l**		1.38
	1.4-2.0 l		1.34
	> 2.0 l		1.30
PHEV			1.00
BEV/FCEV*	**Small**		1.258
	Medium		1.283
	Large		1.299

Light Commercial Vehicles	**Ratio WLTP/NEDC**
All ICEV	1.30
Gasoline	1.22
Diesel	1.31
LPG	1.16
Gas	1.36
HEV Gasoline	1.38

HEV Diesel	1.45
PHEV	1.00
BEV/FCEV*	1.21

*The WLTP to NEDC ratios for BEV and FCEV refer to the electric energy consumption

Finally, results for plug-in hybrid electric vehicles (PHEVs) show a peculiar trend. Due to the differences between the two test procedures (especially in the way they combine results from the charge depleting and charge sustaining tests), the WLTP to NEDC CO_2 emissions ratio strongly depends on the capacity of the electric battery. The ratio quickly decreases as the battery capacity increases. For this reason, also considering the evolution in the battery capacity, an average ratio of 1 has been estimated for PHEV.

5 ANNEX 5: FROM NEDC TO WLTP – TRANSITION TO THE NEW TYPE APPROVAL EMISSIONS TEST UNDER THE CURRENT CARS AND VANS REGULATIONS

The CO_2 emission targets for cars and vans have until now been set on the basis of the emissions resulting from the New European Driving Cycle (NEDC) type approval test. Since 1 September 2017, the NEDC has been replaced by the new Worldwide Harmonised Light Vehicle Test Procedure (WLTP). The WLTP has been designed to better reflect real driving conditions and will therefore provide more realistic fuel consumption and CO_2 emissions values. The WLTP type approval test will be fully applicable to all new cars and vans from 1 September 2019. WLTP-based manufacturer CO_2 targets will apply from 2021 onwards.

The WLTP test is likely to result in increased type approval CO_2 emission values for most vehicles, but the increase will not be evenly distributed between different manufacturers. Due to this non-linear relationship between the CO_2 emission test results from the NEDC and WLTP test-procedures, it is impossible to determine one single factor to correlate NEDC into WLTP CO_2 emission values. A correlation procedure together with a methodology for translating individual manufacturer CO_2 targets have therefore been put in place[51] which will ensure that the CO_2 reduction requirements of the current Regulations under WLTP conditions are of a stringency comparable to those that have been defined under the NEDC conditions.

More precisely, during the period 2017 to 2020, NEDC-based CO_2 targets will continue to apply for cars and vans. All vehicles placed on the market in this period will progressively be certified with both NEDC and WLTP values. The Commission will monitor those values until 2020, which is the first full calendar year in which both NEDC and WLTP values will be available for all new vehicles registered. Based on the 2020 monitoring data (available in 2021), each individual manufacturer's performance on both test procedures will be compared with a view to determining its WLTP-based reference target. That reference target will correspond to the manufacturer's average WLTP-based CO_2 emissions in 2020 adjusted either upwards or downwards depending on how close the manufacturer will be in complying with its NEDC based CO_2 target in 2020. The reference WLTP targets will be used to calculate the manufacturers' annual specific emission targets starting from 2021 using the approach set out in Commission Delegated Regulations (EU) 2017/1499 and 2017/1502. The 2021 targets will be published by the Commission in October 2022[52].

This process allows the cars and vans CO_2 emission targets set for 2020 and 2021 onwards to be maintained after the transition to the WLTP test is completed and to use those targets as the starting point for the new legislation..

[51] Commission Implementing Regulations (EU) 2017/1152 and 2017/1153 and Commission Delegated Regulations (EU) 2017/1499 and 2017/1502.

[52] The monitoring timetable means that the data, on the basis of which the annual targets are calculated, is submitted by Member States in the year following that for which the targets apply, e.g. the 2021 monitoring data needed for calculating the 2021 targets, will be submitted by Member States end February 2022. Following a verification of the correctness of the data, the Commission will confirm and publish the 2021 targets by 31 October 2022.

6 ANNEX 6: REAL WORLD EMISSION MONITORING

JRC Science for Policy Report "Characterization of real-world CO2 variability and implications for future policy instruments " (*Pavlovic, J., Clairotte, M., Anagnostopoulos, K., Arcidiacono, V., Fontaras, G., Ciuffo, B.* (2017), publication pending)

EXECUTIVE SUMMARY

As part of its policy for reducing the greenhouse gas emissions from transport and improving its energy efficiency, Europe has set a target for the average CO_2 emissions of new passenger cars at 95 gCO_2/km, applying from 2021 on. Over the past years, improvements in fuel efficiency have been claimed, on the basis of emission tests, which are part of the type approval of the vehicles. Nevertheless there is increasing evidence that fuel consumption improvements are only partly visible in real-world operating conditions, since they originate, at least in part, from test-oriented vehicle optimizations and test-related practices. As a result, the offset between officially reported values and real-world vehicle CO_2 emissions has increased year by year, and is estimated to be around 40% for 2015/2016.

There are three main reasons why a high and increasing difference between officially reported and actual CO_2 emissions of vehicles constitutes a problem: a) it undermines the collective effort to reduce greenhouse gas emissions in Europe, b) it creates an unfair playing field for different competitors, and c) it affects the credibility of vehicle manufacturers amongst vehicle buyers. Different stakeholders have been suggesting approaches for dealing with the gap both to provide consumers with more reliable information and to ensure that progresses to meet fuel-economy/CO_2 emission standards are also visible in real life. Among the different options, the following ones have been more frequently advanced: i) the development of an RDE test for CO_2 and fuel consumption, ii) the development of a fleet-monitoring system based on a fuel consumption meter introduced in all new vehicles, iii) the use of statistical and/or model-based approaches to correct the type-approval figures in order to be closer to the real-life conditions[53]. However, a fundamental question remains unsolved: does a single real-life fuel consumption figure make sense or alternative approaches (distributions, ranges, customized figures, etc.) need to be developed? Furthermore, the development of a new approach will require time to have it fully developed and validated.

In this light, the present study aims at characterizing the uncertainty (variability) in the vehicle fuel consumption. This should help to develop an appropriate and effective approach to deal with the gap between type-approval and real-world vehicle fuel consumption, in the context of the CO_2 target setting and compliance monitoring as well as for informing consumers on the CO_2 emissions and fuel consumption (car labelling).

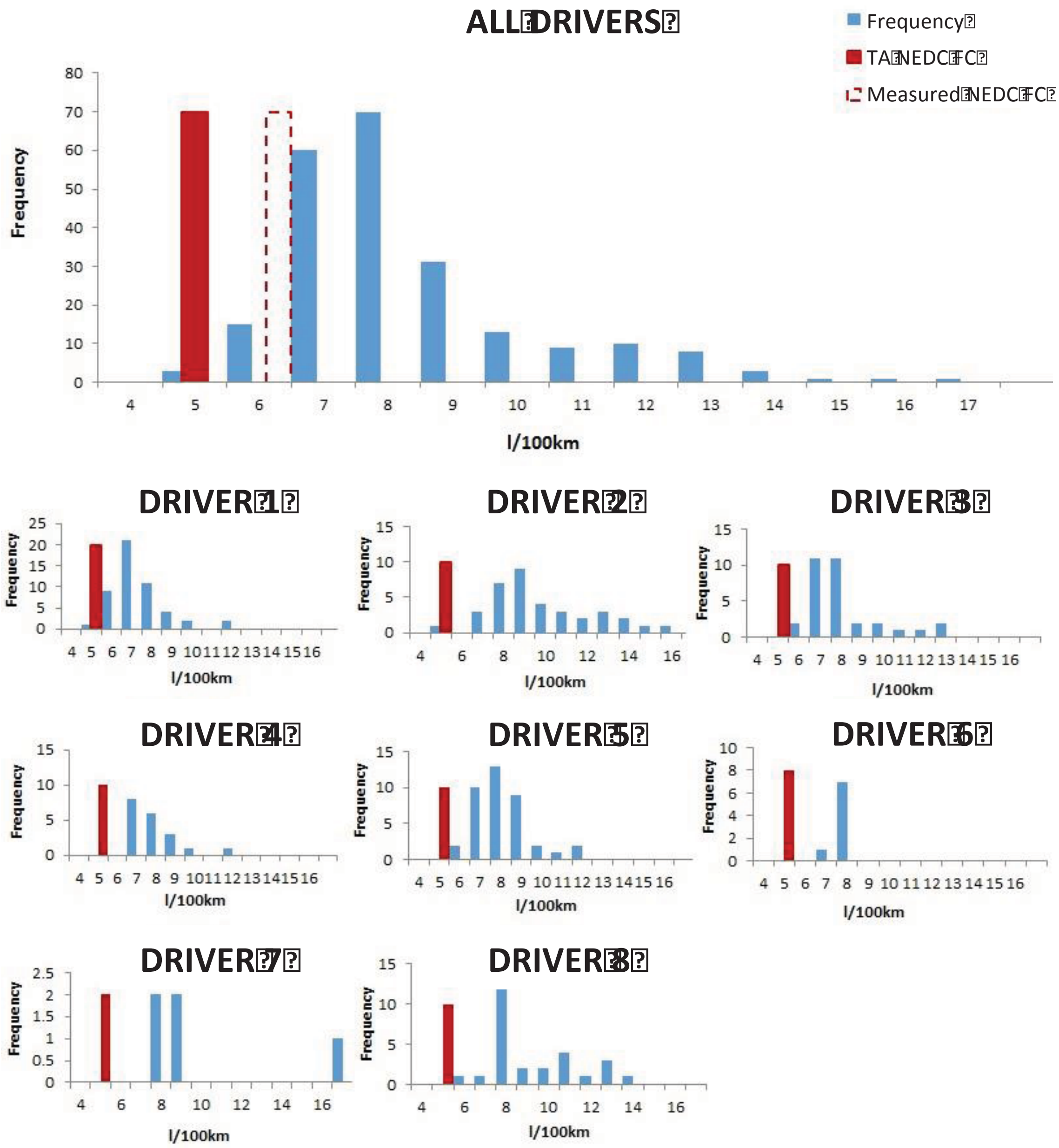
Two types of data sources are used in the analysis, namely (i) data collected during a period of ~6 months from the same vehicle driven by different drivers and in different conditions, and (ii) data collected from different vehicles tested by a few drivers on a limited number of routes. Combining these two sets of data allowed to merge a wider coverage of testing conditions (first data set) with a wider coverage of vehicle technologies (second data set).

As shown in Figure 5, the variability of the vehicle fuel consumption over different operating conditions is high (ranging from 5 to 13 l/100km in 95% of the cases), both for the same

[53] Scientific Advice Mechanism (SAM) (2016): Closing the gap between light-duty vehicle real-world CO2 emissions and laboratory testing, High Level Group of Scientific Advisors, Scientific Opinion 01, Brussels, 11 November 2016

driver and for different drivers. The average fuel consumption measured for all trips is 8 l/100km and the median fuel consumption is 7.4 l/100km. As the type-approval value for the vehicle is 5.5l/100km ("TA NEDC FC"), the mean and median value imply a gap of 45%, and 35%, respectively, which is overall in line with the evidence reported in the existing literature.

Figure 5: Overview of results: fuel consumption of individual drivers and all drivers combined



These findings put into question the meaningfulness of solutions, which try to characterize the fuel consumption of a vehicle with a single central figure measured ex-ante.

From the perspective of monitoring the real-world fuel efficiency improvements under a regulatory target, one may wonder how to ensure that a single figure corresponds to the average of the fuel consumption experienced by all drivers using the same vehicle. Similarly, from the perspective of providing reliable information to the users, one may also question the value of a median figure when the variability for different drivers over different trips can be so high.

The above figure also shows the fuel consumption measured in the Vehicle Emission LAboratory (VELA) of the Joint Research Centre from the same vehicle running a NEDC test ("Measured NEDC FC"). As already reported in the literature (please refer to Table 1 in the report), the NEDC TA value is systematically lower than the results of measurements carried out in an independent lab. Introducing a more robust test procedure, such as WLTP, will therefore significantly increase the representativeness of the lab-based test. Since, as of September 1st 2017, the WLTP has replaced the NEDC as test procedure to be used in the emission type-approval of light-duty vehicles, it is expected that the vehicles that will be introduced in the market in the near future will show a more realistic single value of fuel consumption and CO_2 emissions.

The results achieved in the present study suggest however that there is further potential to enhance the existing type-approval system by coupling it with additional instruments, such as a fleet-wide fuel consumption monitoring system (to monitor the evolution of the gap between real-world and type-approval figures) and/or tools able to provide users with customized fuel consumption information derived on the basis of driver-specific conditions of vehicle use. Concerning this latter point, the Green Driving tool[54] developed by the JRC is a first attempt in this direction.

[54] http://green-driving.jrc.ec.europa.eu

7 ANNEX 7: EMPLOYMENT AND QUALIFICATION

Building on a stakeholder meeting[55] dedicated to the social impacts of the transition to electrified powertrains, this Annex summarises, based on different scenarios, how different levels of uptake of electrified powertrains may affect employment and skills. It also lists possible measures on how to address social impacts.

Employment

The automotive value chain until 2025 and beyond

A recent analysis by Deloitte underlines the multitude of drivers the automotive value chain is faced with until 2025 and beyond[56]. Key challenges include digitalisation, new business models such as car sharing, and the uptake of alternative powertrains. The study develops four different scenarios for a globally operating manufacturer looking *inter alia* at the impact on employment and skills. Under two scenarios the uptake of alternative powertrains will reach between 33% and 36% of annual global sales of the manufacturer in 2025 and nearly 100% in 2030, whereas the other two scenarios assume an uptake of between 18% and 21% in 2025 and around 55% in 2030. Hence, in all scenarios the global share of alternative powertrains is at least 18% in 2025 and 55% in 2030.

The scenarios show that the effect on employment and skills is affected by more factors than the speed in the uptake of alternative powertrains. Whereas an alternative powertrain share of 33% combined with a slowdown in vehicle sales of 24% due to car sharing would for that manufacturer result in the loss of around 15 000 employees in production, an additional 13 000 IT related jobs would be created in the digital business contributing then 20% of the manufacturer's revenues. Under the 36%-scenario the manufacturer is also faced with 24% decrease in car sales, loses the digital business to IT giants and becomes a mere hardware platform provider using manufacturing 4.0 at large scale. As a consequence, the manufacturer would lose 24% of its workforce. By contrast under the 21%-scenario the manufacturer's workforce would be reduced by 50% in a scenario of consumers' reduced willingness to pay due to lost trust in the car industry. Under the 18%-scenario the manufacturer's workforce would increase by 5% due to a large remaining share of combustion engines and no major change in the manufacturer's business model due to a limited impact of digitalisation.

The impact of electrification of powertrains trains on direct employment and skills

The study "Electric Mobility and Employment"[57] (ELAB) analysed how the electrification of the powertrain effects personnel structures. It quantified these effects on employment for an "ideal" production of main systems for conventional and electric vehicles for a fix production capacity of 1 million powertrains. In addition, the study assessed how changes in tasks affect

---

[55] Stakeholder meeting "Revision of the Regulations on CO_2 emissions from light-duty vehicles (post-2020) – Impact on jobs and skills in the automotive sector", Brussels, 26 June 2017.

[56] Deloitte: The Future of the Automotive Value Chain – 2025 and beyond, https://www2.deloitte.com/de/de/pages/consumer-industrial-products/articles/automotiv-value-chain-2025.html

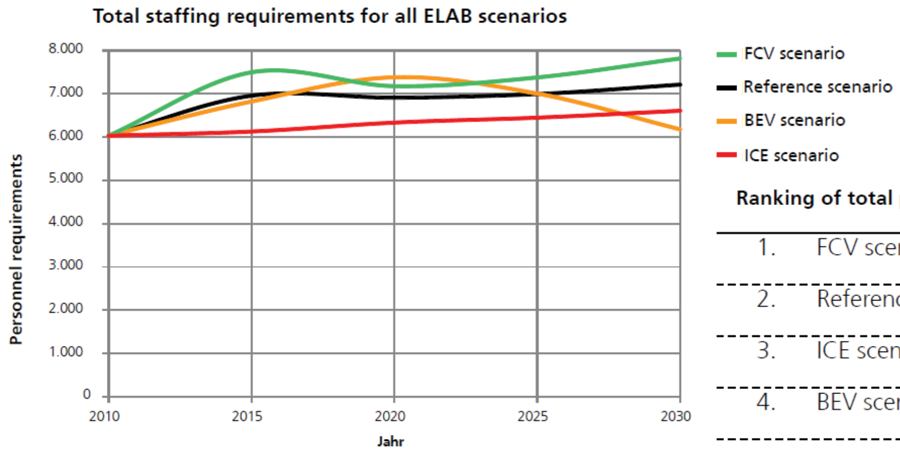
[57] Fraunhofer IAO (2012): Elektromobilität und Beschäftigung – Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB), http://www.muse.iao.fraunhofer.de/content/dam/iao/muse/de/documents/AbgeschlosseneProjekte/elab-abschlussbericht.pdf . The study does not consider how much the workforce is affected along the value chain, e.g. component suppliers, not does it look at labour structures. These issues are assessed in a follow-up study "ELAB2". Results were not available yet.

skill requirements. For the analysis the study assumed different scenarios for the uptake of alternative powertrains.

In the reference scenario BEVs would reach a share of 10% and plug-in hybrids (including range-extender) of 30%. Under an ICE-scenario conventional powertrains would remain dominant in 2030 with a market share of more than two thirds, while BEVs would not enter the market. Under a BEV-scenario BEVs would constitute 40% and fuel cells 10% of new vehicles in 2030, while conventional powertrains would be out of the market in 2030. Under an FCV-scenario fuel cells would reach a market share of 40%, plug-in hybrids around 30% and BEVs and conventional powertrains around 10%.

When assessing how employment in production changes under each scenario, the impacts change over time. Under all scenarios – except for the very conservative ICE-scenario with no uptake of BEVs – an immediate increase in employment is expected (see Figure X). Under the BEV-scenario peak in employment will be reached after 10 years and will then decrease. In all scenarios employment will be higher in 2030 compared to the starting point. However, the FCV scenario is the most labour-intensive scenario, whereas the BEV-scenario is the least labour intensive scenario in the long run. During the transition phase the role of hybrid vehicles has an important effect on employment as a result of more components required in these vehicles.

Figure 6: Employment impacts of different ELAB scenarios



Ranking of total personnel requirements 2030

1.	FCV scenario	7.816 Emp
2.	Reference scenario	7.213 Emp
3.	ICE scenario	6.607 Emp
4.	BEV scenario	6.173 Emp

Socio-economic impacts to the wider economy

A series of studies[58] assessed the socioeconomic impact of the uptake of low- and zero-emission vehicles in Europe. Building on techno-economic modelling, four different scenarios are tested. In the reference scenario it is assumed current technology and vehicle efficiency does not progress further. A second scenario assumes that the 2021 CO_2 standards are met without further action beyond that date. Another scenario assumes a strong penetration of advanced powertrains which would account for 90% of sales by 2050 and hybrid-electric vehicles for the remaining 10%. Finally in technology specific scenarios different penetration rates for alternative powertrains are assumed.

The main conclusion of the macroeconomic assessment is that an increase in vehicle efficiency has a positive impact on the wider economy in Europe including employment. GDP will benefit from lower oil imports as a result of an improved trade balance and consumers as

[58] https://www.camecon.com/how/our-work/fuelling-europes-future/

well as businesses are better off due to lower fuel spending. In the technology specific scenarios three trends emerge from the modelling. First, the reduction in total cost of ownership allows consumers to spend their incomes on other goods and services which is typically spent on leisure activities or consumer services that are inherently labour intensive. Secondly, the additional spending on extra technology in the automotive sector increases employment throughout the associated manufacturing supply chain. Finally, the expenditure on supporting infrastructure results in additional employment in the construction sector.

In the technology specific scenarios most additional employment is created in the manufacturing sector with an increase of between 350,000 and 550,000 jobs. Net employment increases most in the scenario with the highest uptake of alternative powertrains. Assuming that electric vehicles will have a share of 9.5% in 2020 and 80% in 2030, with the remaining 20% being hybrid-electric vehicles, direct and indirect jobs in the automotive value chain increase by 591,200 and economy-wide 508,800 jobs are created due to avoided oil use. This takes account of jobs lost in the transition such as in the refining industry.

The impact of Electrically Chargeable Vehicles on the EU economy – A literature review and assessment

A literature review[59] of recent studies on employment impacts of a higher share of electrified powertrains, carried out for ACEA, confirms that the majority of studies conclude with positive impacts on employment as is summarised in the following table:

Table 8: Summary of literature review (from FTI Consulting, 2017)

[59] FTI Consulting (2017): The impact of Electrically Chargeable Vehicles on the EU economy, A literature review and assessment. Study prepared for ACEA: http://www.fticonsulting.com/~/media/Files/emea--files/insights/reports/impact-electrically-chargeable-vehicles-eu-economy.pdf

Region	Author (Year)	Title	Impact
Employment impact			
Germany	Bundestag (2013)	*The future of the automotive industry*	Mixed Depending on the growth of productivity versus the growth of value creation (assumed at 2.7% p.a. in Germany) ECVs impact on employment ranges from -68,000 to 138,000 in 2030
EU	CE Delft. (2012)	*Literature Review on Employment Impacts of GHG reduction policies for transport*	Positive This literature review reports that most studies find a positive impact of EVs on employment based on a simplified theory
EU	CE Delft (2013)	*Impact of Electric Vehicles*	Positive (but benefits to Hybrid/Fuel efficient market not necessarily pure EV) 110,000 new jobs created in the EU by 2030 in production and R&D
EU	Cambridge Econometrics Ricardo-AEA (2013)	*Economic Assessment of Low Carbon Vehicles*	Positive Tech 1 Scenario[5]: European employment increase of 443,000 jobs; CPI Scenario[6]: increase of 356,000 jobs By 2050 jobs increase to 2.3m in all low-carbon scenarios examined
EU	EC (2011)	*Roadmap for moving to a Competitive Low Carbon Economy*	Positive Net job creation to be an increase of 0.7% (~1.5million jobs) by 2020 compared to BAU.
Global	Mckinsey & Company (2011)	*Boost!*	Positive 420,000 additional FTEs in global powertrain. Employment shifts from industrialised to emerging countries.
EU	Cambridge Econometrics et al. (2013)	*Fuelling Europe's Future*	Positive Between 660,000 and 1.1m net jobs could be generated by 2030. This increases to between 1.9m and 2.3m by 2050.

However, the study points out that the positive impact on employment rely on some critical assumptions including on labour intensity and value-added of the technologies as well as the EU's continued technological leadership.

EU Skills Panorama

The EU Skills Panorama on the automotive sector and clean vehicles[60] concluded that the continued development of cleaner vehicles will impact considerably on the occupational and skills profile of the sector. It estimated that by 2025 the automotive industry will have to fill 888.000 jobs mainly due to the aging of the workforce and the forecasted growth of production in the sector. Over half of the total job openings to 2025 are forecast to require high-level qualifications (461,000 jobs). This includes 213,000 new jobs requiring high-level qualifications, which partially compensates a decline in the number of jobs requiring low- and medium-level qualifications.

At the national level, the EU Skills Panorama forecasts the largest expansion in automotive employment for Romania (an additional 48,040 jobs, representing a 38% increase in sector employment by 2025) and the United Kingdom (an additional 33,050 jobs, representing a 25.8% increase). Other Member States anticipated to have an above-average employment growth include Finland, Spain and Hungary. The small Latvian automotive sector is also expected to grow considerably. Germany is expected to continue dominating automotive employment in the EU with 850,650 automotive workers in 2013 representing 37.9% of the

[60] European Commission (2014): EU Skills Panorama 2014: Automotive sector and clean vehicles, http://skillspanorama.cedefop.europa.eu/sites/default/files/EUSP_AH_Automotive_0.pdf

total automotive industry in the EU with a small net increase in jobs by 2025. In other countries, such as Poland, France and Italy, employment in the sector is expected to decline.

Impact on regional automotive clusters

The transition to electrified powertrains may affect employment more significantly in regions with a strong automotive industry. The regions with the highest number of persons directly employed in automotive manufacturing are located in South Germany (Baden-Württemberg/Stuttgart and Bayern) followed by Île de France.

A recent study[61] analysed how employment in the automotive sector may change in the region of Baden-Württemberg in Germany with the highest number of people directly employed in automotive manufacturing, if in 2030 nearly 50% of all new vehicles will have an electric powertrain, 25% ICE with and 25% with a conventional powertrain. The study concluded that Baden-Württemberg could benefit from 18 000 additional jobs compared to the reference scenario 2013, of which 5 600 additional jobs for conventional technologies, 6 900 additional jobs related to efficiency technologies and 5 600 related to electrification. If more of the value chain for electric vehicles, mainly production of battery cells, will be located in the region additional 5 800 jobs could be created.

Qualification

In terms of skills requirements for future automotive sector, the ELAB-study[62] points to the increasing importance of electrics/electronics compared to mechanics. New skills are needed to deal with high voltage systems, hazardous materials (e.g. lithium), and new assembly tasks (electric motors). New technical competencies (e.g. electrochemical coating in the case of fuel cell systems) and specific knowledge related to hydrogen storage (e.g. high pressure).

However, independently from the uptake of alternative powertrains, the automotive industry – as all other sectors – will be faced with fundamental changes in labour markets. Demographic changes will significantly reduce the labour force potential until 2030 and beyond. In combination with a trend towards more academic qualification, the automotive sector may be faced with a shortage in employees for powertrain production. [63]

As part of the GEAR 2030 process a "Human Capital" Project Team[64] was established to "Identify the impact on employment in the EU, prepare approaches for mitigating possible

---

[61] e-mobil BW GmbH – Landesagentur für Elektromobilität und Brennstoffzellentechnologie, Fraunhofer-Institut für Arbeitswirtschaft und Organisation IAO, Ministerium für Finanzen und Wirtschaft Baden-Württemberg (2013): STRUKTURSTUDIE BWe mobil 2015 Elektromobilität in Baden-Württemberg.

[62] Fraunhofer IAO (2012): Elektromobilität und Beschäftigung – Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB), http://www.muse.iao.fraunhofer.de/content/dam/iao/muse/de/documents/AbgeschlosseneProjekte/elab-abschlussbericht.pdf . The study does not consider how much the workforce is affected along the value chain, e.g. component suppliers, not does it look at labour structures. These issues are assessed in a follow-up study "ELAB2". Results were not available yet at the time of writing.

[63] Fraunhofer IAO (2012): Elektromobilität und Beschäftigung – Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB), http://www.muse.iao.fraunhofer.de/content/dam/iao/muse/de/documents/AbgeschlosseneProjekte/elab-abschlussbericht.pdf . The study does not consider how much the workforce is affected along the value chain, e.g. component suppliers, not does it look at labour structures. These issues are assessed in a follow-up study "ELAB2". Results were not available yet.

[64] http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=8640

negative consequences and develop a strategy for ensuring that the necessary skills will be available in 2030" for the EU automotive industry. The work assessed the landscape of existing initiatives across the EU, looked at what trends will impact the sector up to 2030. Moreover, it investigated the skills and human capital needs as we experience the digitalisation of the automobile industry. The GEAR2030 Project Team "Human Capital" concludes that SMEs are at the nexus of addressing skills challenges in the automotive value chain. It also argues that EU and Member State actions should focus on developing digital skills and that upskilling and reskilling will become the priority issues in corporate HR strategies to meet future job requirements.

Possible measures to address social implications

Regions with a strong automotive sector and clusters of rather closely integrated manufacturers and suppliers of components of conventional powertrains may face particular challenges by the transition to alternative powertrains if this happens at high pace.

Stakeholders have identified several actions to address these challenges. Actions include industrial collaboration, building new value chains, creating social dialogue, supporting the employability and retraining of workers / lifelong learning, stimulating entrepreneurship and creating new job opportunities in circular economy. Financial support by existing and newly developed instruments (e.g. European Structural and Investment Funds, Innovation Fund, Global Adjustment Fund) could be used to support regions to successfully cope with the transition. Regional regeneration strategies could be developed with the help of regional task forces composed of all relevant stakeholders to develop smart specialisation/transition strategies including re-training and re-employment as well as the promotion of entrepreneurship and start-ups.

To address the challenges of upskilling and reskilling GEAR2030 made the following recommendations:

- **Facilitating the vertical and horizontal transferability of skills and skilled labour force:** make it easier for workers to have their skills and knowledge recognised and transferred throughout the value chain (vertical) and everywhere in the EU (horizontal).
- **Creating a framework of standard job roles, working with, using and building upon the ESCO classifications (to ensure horizontal/pan-European comparability):** To provide improved knowledge of specific roles, standard job framework descriptions and potential career tracks enabling coordination and promotion of professional development courses/training on the job.
- **Individual Skills Passport to document more non-formal learning, increasing vertical employability throughout the supply chain:** validation of informal competences (identification of acquired skills, documentation, assessment and certification), e.g. via individual Skills Passports.

8 ANNEX 8: ADDITIONAL INFORMATION CONCERNING THE ASSESSMENT OF THE ECONOMIC, ENVIRONMENTAL AND SOCIAL IMPACTS OF THE DIFFERENT POLICY OPTIONS

8.1 Emission targets: metric

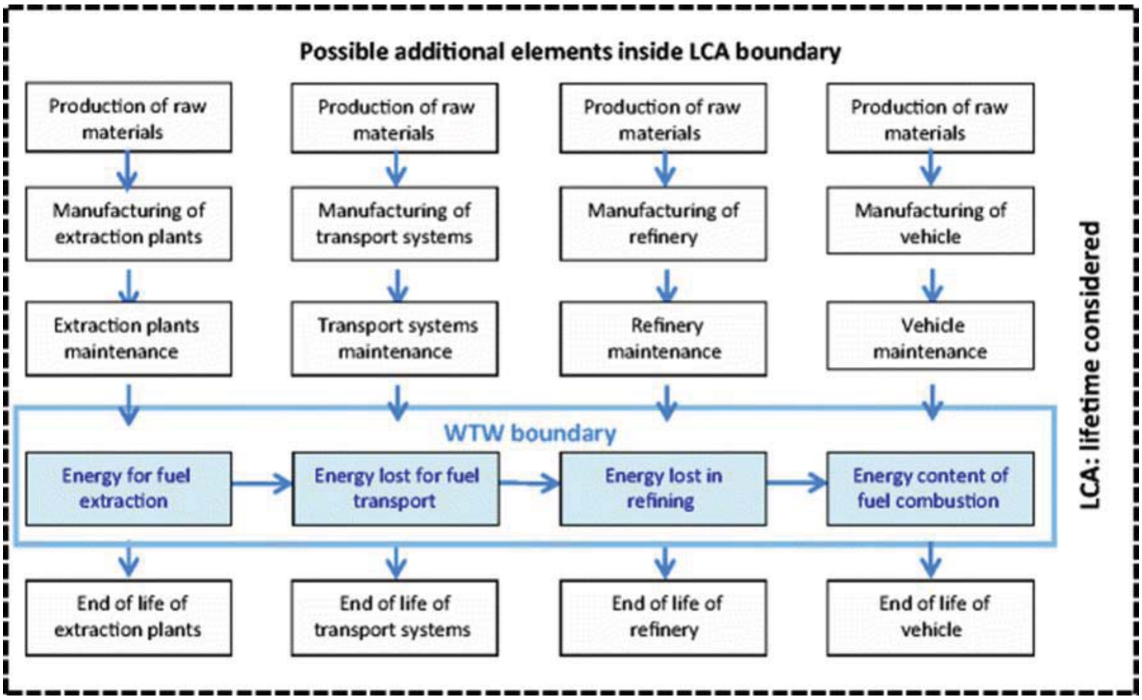
8.1.1 Methodological considerations concerning Well-to-Wheel (WTW) and life-cycle analysis (LCA) approaches

When considering WTW or LCA approaches, discussion exists over which method provides a better balance between limited complexity and data availability while capturing the most relevant elements as regards GHG emissions related to vehicles (see Moro and Helmers, 2017[65] for more information).

The main advantage of the WTW approach as a framework for analysis is that it allows comparing results across different contexts and allows comparing over time as opposed to , a full LCA approach. A WTW analysis also has the advantage of clearly defined boundaries which facilitates data collection and reporting. WTW can be regarded as a simplified LCA, focusing on the energy consumption and GHG emissions of the preparation of road transport fuels and their operation, while ignoring other elements such as the impacts of manufacturing and decommissioning of the equipment.

A schematic overview on the different boundaries of a WTW and LCA approach is visualised in Figure 7.

Figure 7: Schematic representation of WTW boundaries, completed by possible additional elements of an LCA system describing a vehicle



[65] Moro, A., Helmers, E.: A new hybrid method for reducing the gap between WTW and LCA in the carbon footprint assessment of electric vehicles. Int J Life Cycle Assess (2017) 22: 4–14. DOI 10.1007/s11367-015-0954-z

Source: Moro A. and Helmers E. (2017)

8.1.2 Considerations regarding well-to-wheel emissions

This sub-section looks into the GHG emissions that occur in the fuel production and use of different types of vehicles – the 'well-to-wheel' approach - based on selected existing studies.

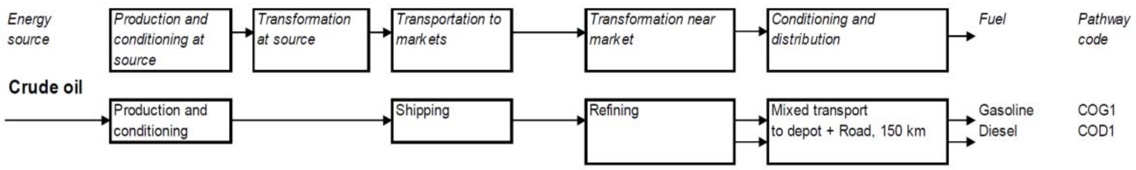
The scope of the well-to-wheel (WTW) analysis considers energy and GHG emissions balances related to the fuel production (Well-to-Tank – WTT) and related to the vehicle use (Tank-to-Wheel – TTW). The WTW emissions are assessed for a wide range of automotive fuels and powertrain options in the EU by the "J.E.C." research collaboration[66] between the European Commission's Joint Research Centre (JRC), the European Council for Automotive R&D (EUCAR) and the research division of the European Petroleum Refiners Association (CONCAWE). The assessment is updated periodically; the currently latest available version 4.a dates from the year 2014 (JEC, 2014)[67,68,69]; the WTT emissions of electricity have been updated more recently by JRC (Moro and Lonza, 2017)[70].

8.1.2.1 Well-to-Tank (WTT) analysis

Fossil fuel: Diesel and gasoline

The WTT ('upstream') energy and GHG emissions related to fossil fuels that are addressed in the JEC (2014) analysis cover the chain from extraction, transportation and refining as shown in Figure 8 below. The analysis aims at quantifying marginal emissions in order to correctly assess the impact of substituting fossil fuels through alternative options.

Figure 8: Conventional fossil fuels pathways



Source: JEC (2014), WTT report version 4.a

The key elements can be summarised as follows:

- Emissions from crude oil production and conditioning at source originate mainly in the energy chain required to extract and pre-treat the oil, and the flaring and venting and fugitive losses of associated volatile hydrocarbons, which vary across regions and fields. These are analysed for the different regions that supply the European market to obtain representative values for GHG emissions and energy use related to crude production and conditioning at source. For the WTT calculations the energy and GHG associated with the marginal crude available to Europe are calculated. This marginal crude is likely to

[66] http://iet.jrc.ec.europa.eu/about-jec/welcome-jec-website

[67] JEC - JRC-EUCAR-CONCAWE collaboration (JEC 2014): **Well-to-Tank Report - Version 4.a**

[68] JEC - JRC -EUCAR-CONCAWE collaboration (JEC 2014): **Well-to-Wheels Report - Version 4.a**

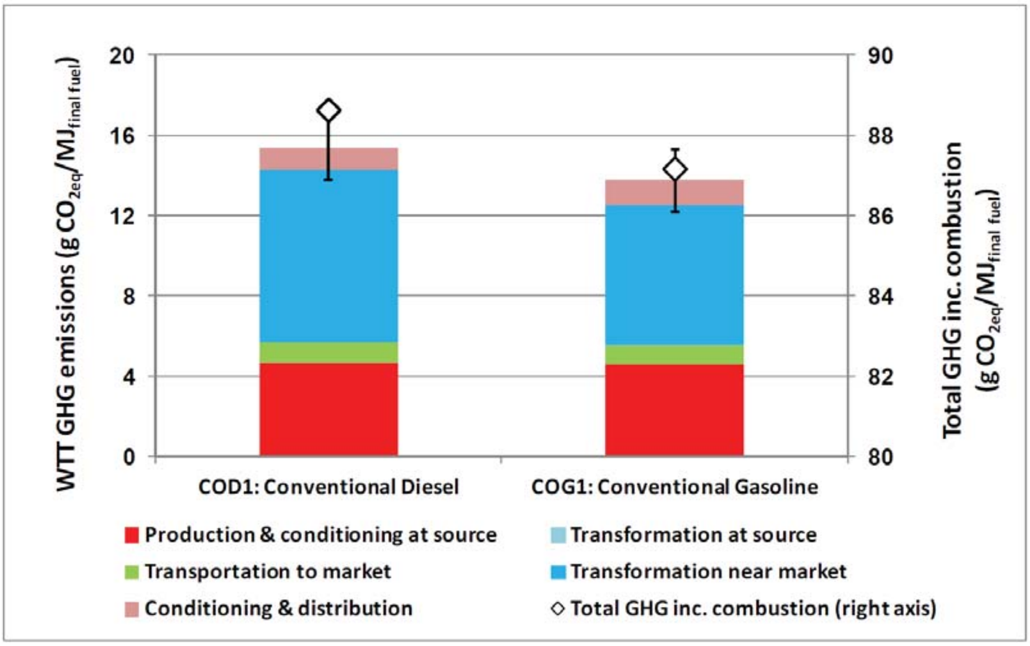
[69] JEC - JRC -EUCAR-CONCAWE collaboration (JEC 2014): Tank-to-Wheels **Report - Version 4.a**

[70] Moro, A., Lonza, L. (2017): Electricity carbon intensity in European Member States: Impacts on GHG emissions of electric vehicles. Transportation Research Part D, http://dx.doi.org/10.1016/j.trd.2017.07.012

originate from the Middle East where the amount of energy needed for production tends to be at the low end of the range.

- The GHG emissions stemming from the transportation of crude to Europe are calculated.
- Refining of crude oil is the most energy-intensive process in the fossil fuel supply chain. In order to best estimate the savings from substituting conventional fuels, the study assessed how the EU refineries would have to adapt to a marginal reduction in demand, differentiating between gasoline and diesel.
- Finally, emissions related to the distribution of gasoline and diesel are considered.

Figure 9: WTT GHG emissions of conventional diesel and gasoline



Source: JEC (2014), WTT report version 4.a

Overall, the WTT GHG emissions for gasoline and diesel fuel amount to 13.8 and 15.4 g CO_2eq per MJ of final fuel, respectively. Refining is the most energy- and emission-intensive step, followed by the crude production (Figure 9).

Regarding the changes in the WTT emissions of conventional diesel and gasoline in Europe over the next decades, according to JEC (2014), the use of unconventional oils in the European fuel supply is likely to remain limited until 2020.

Council Directive 652/2015 lays down rules on calculation methods and reporting requirements regarding the greenhouse gas intensity of fuels, in accordance with the Fuel Quality Directive 98/70/EC[71].

Electricity

The WTT emissions of electricity as a fuel for vehicles are based on Moro and Lonza (2017), who updated and expanded the JEC (2014) analysis. Moro and Lonza provide the GHG intensity of the electricity consumed in the year 2013 at the EU-28 level, and by Member

[71] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015L0652&from=EN

State. While noting there are important differences in the carbon-intensity across countries, this section focuses on average EU28 figures only, as shown in Table 9.

The WTT GHG emissions (considering CO_2, CH_4 and N_2O) include upstream emissions caused by the extraction, refining and transportation of fuels, as well as, the emissions related to the generation of electricity (i.e. combustion emissions), while assigning GHG emission credits for heat produced by CHP plants. In addition, losses due to own-consumption in power plants, pump storage and transmission losses occurring at the high, medium and low-voltage levels are taken into account, considering that charging of electric vehicles may to a large extent take place at the low-voltage level.

Table 9: GHG emission intensity of electricity in the year 2013, EU-28 average

gross electricity production - combustion only	340 g CO_{2eq}/kWh
gross electricity production - combustion plus upstream	387 g CO_{2eq}/kWh
net electricity production - including upstream	407 g CO_{2eq}/kWh
electricity supplied- including upstream	417 g CO_{2eq}/kWh
electricity consumed at high voltage level - including upstream	428 g CO_{2eq}/kWh
electricity consumed at medium voltage level - including upstream	432 g CO_{2eq}/kWh
electricity consumed at low voltage level - including upstream	447 g CO_{2eq}/kWh

Source: Moro and Lonza, 2017

In order to provide an **indication** of the possible evolution of the WTT emissions of electricity as road transport fuel for 2020, 2025 and 2030 in line with the EU's energy and climate targets, the following calculations were performed.

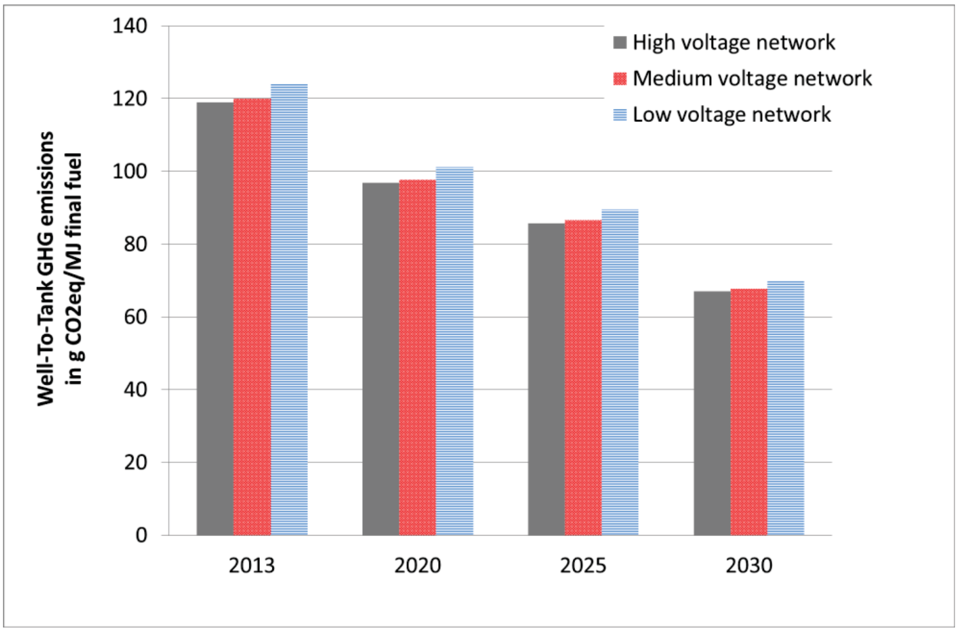
The trajectory of the carbon intensity of the European electricity and steam production over the period 2010-2030, as projected by the PRIMES model in the *EUCO30* scenario[72], was applied on the WTT electricity emissions provided by Moro and Lonza (2017). To this end, in a first step the WTT GHG emission intensity for the year 2013 was back-calculated for the year 2010, taking into account the observed reduction in the CO_2 intensity of electricity and steam generation. On these 2010 WTT emissions, the relative reductions in the carbon intensity of electricity and steam production between the years 2010, 2020, 2025 and 2030 - as modelled by PRIMES – were applied.

On that basis, the EU-28 average WTT GHG emissions at the low-voltage network would be 101 gCO_2eq/MJ (364 gCO_2eq/kWh) in 2020, 90 gCO_2eq/MJ (322 gCO_2eq/kWh) in 2025, and 70 gCO_2eq/MJ (252 gCO_2eq/kWh) in 2030, as shown in Figure 10.

Obviously, these figures need to be interpreted as **rough estimations** only as the simplified approach does not account for any (rather probable) changes in the losses assumed and in the upstream emissions; moreover, it is implicitly assumed that emissions of non-CO_2 GHG decrease proportionally to that of CO_2.

[72] https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf

Figure 10: WTT GHG emissions of the EU electricity consumed at the high, medium and low voltage level in 2013, 2020 and 2030



Source: 2013 data from Moro and Lonza (2017); 2020/2030 estimates derived by applying trends of the direct CO_2 emission intensity from PRIMES EUCO30 scenario on the WTT emissions reported in Moro and Lonza

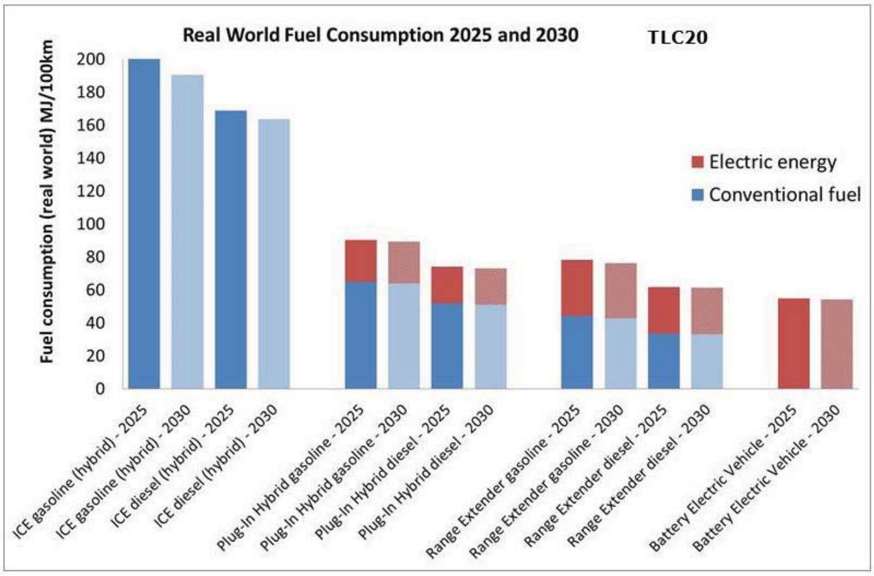
8.1.2.2 Tank-to-wheel analysis

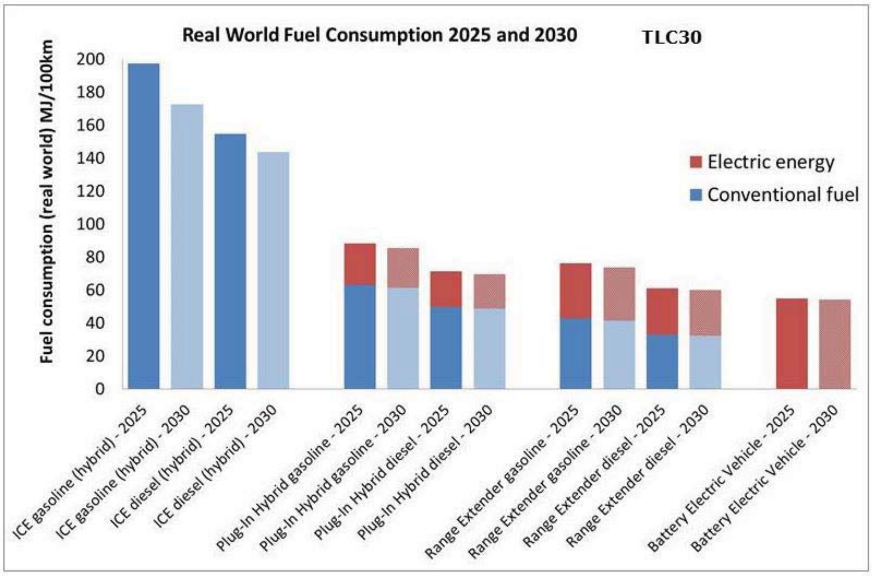
The Tank-to-wheel analysis in this sub-section is based on 'real world' energy consumption figures as used elsewhere in the Impact Assessment. As an illustrative example, the energy consumption of a representative vehicle of the 'lower-medium' category has been considered.

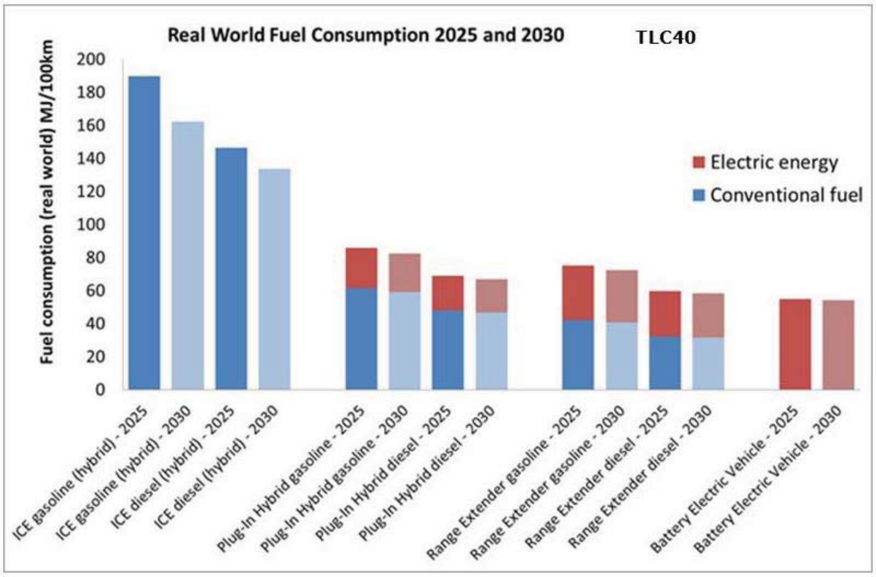
The specific energy consumption of various vehicle types for the years 2025 and 2030 is displayed in Figure 11 for three different policy options regarding the EU-wide fleet CO_2 target level (TLC20, TLC30, TLC40).

On the basis of the specific fuel consumption, the TTW (exhaust) CO_{2eq}-emissions are calculated through the fuel specific CO_2 emission factors used in the Impact Assessment. CH_4 and N_2O emissions are taken from the JEC (2014) assessment that considers the EURO6 limits for 2020+ vehicle configurations; they are left unchanged between 2020 and 2030.

Figure 11: Specific energy consumption of different passenger car configurations (lower-medium segment) in 2025 and 2030 under different EU-wide CO_2 target options as defined in this Impact Assessment







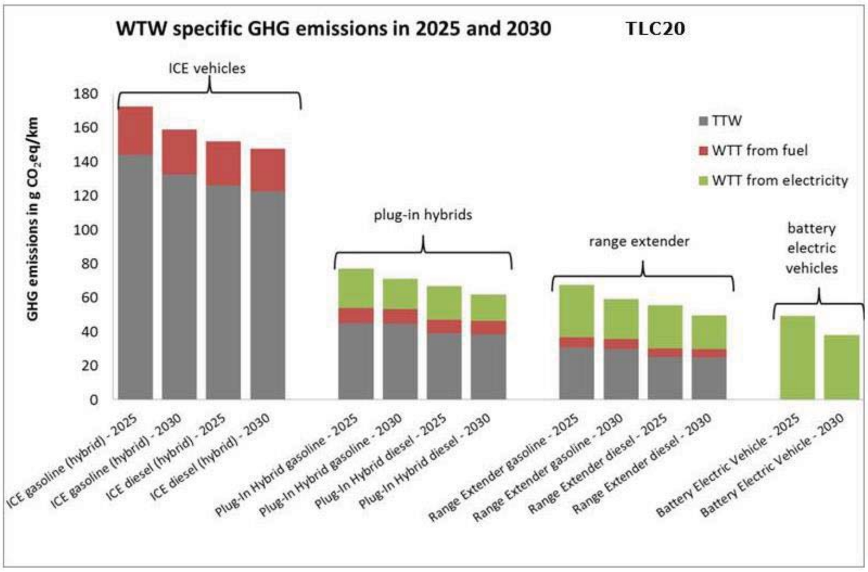
8.1.2.3 Well-to-Wheel analysis

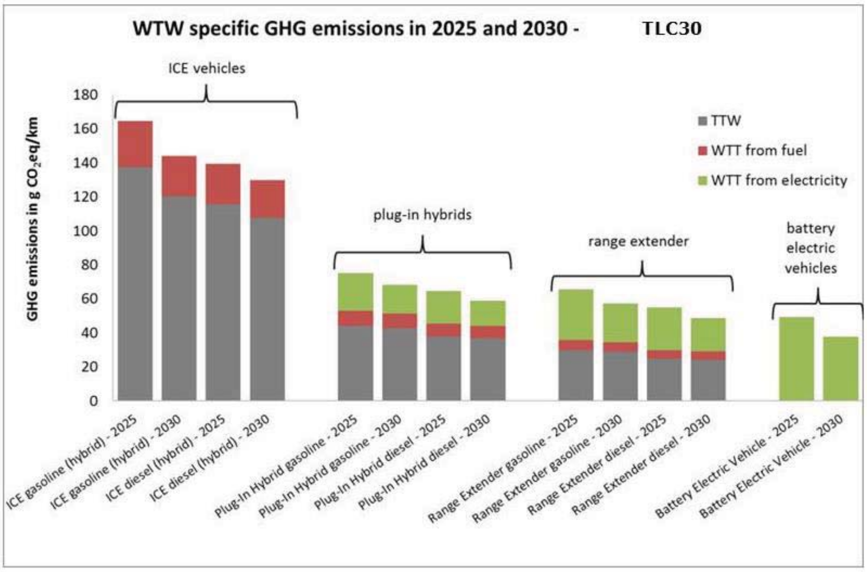
This section brings the information from the previous sections together for a selected number of vehicle types, providing the GHG emission balances that occur from a Well-toWheel (WTW) perspective.

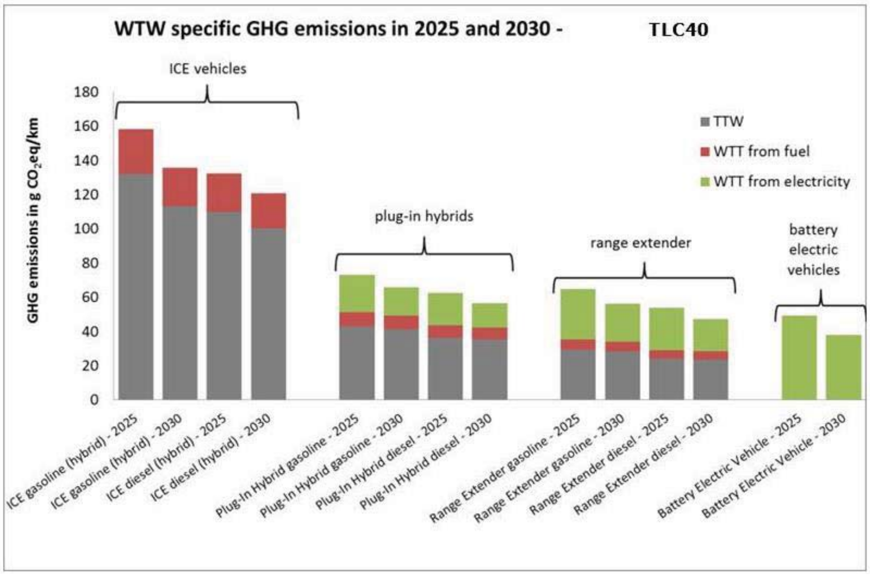
Figure 12 summarises the WTW GHG emissions for 2025 and 2030 passenger car configurations for three CO_2 target level options (TLC20, TLC30 and TLC40). The WTW emissions are disaggregated into those that relate to the use of the vehicle (TTW) and those that stem from the fuel production (WTT), the latter being split into fossil fuel production and electricity generation and distribution. Note that for electric vehicles, charging at the low voltage level was assumed.

The figure illustrates the difference between ICEV and EV in terms of WTW emissions, but also clearly shows the importance of the evolution of the electricity generation mix, which increases with higher degrees of electrification up to the extreme of the battery-electric vehicles.

Figure 12: WTW GHG emissions from different passenger car configurations (lower-medium size segment) in 2025 and 2030 under different EU-wide CO_2 target options as defined in this Impact Assessment


WTW specific GHG emissions in 2025 and 2030
TLC20
ICE vehicles
plug-in hybrids
range extender
battery electric vehicles
TTW
WTT from fuel
WTT from electricity
GHG emissions in g CO2eq/km
ICE gasoline (hybrid) - 2025
ICE gasoline (hybrid) - 2030
ICE diesel (hybrid) - 2025
ICE diesel (hybrid) - 2030
Plug-In Hybrid gasoline - 2025
Plug-In Hybrid gasoline - 2030
Plug-In Hybrid diesel - 2025
Plug-In Hybrid diesel - 2030
Range Extender gasoline - 2025
Range Extender gasoline - 2030
Range Extender diesel - 2025
Range Extender diesel - 2030
Battery Electric Vehicle - 2025
Battery Electric Vehicle - 2030


WTW specific GHG emissions in 2025 and 2030 -
TLC30
ICE vehicles
plug-in hybrids
range extender
battery electric vehicles
TTW
WTT from fuel
WTT from electricity
GHG emissions in g CO2eq/km
ICE gasoline (hybrid) - 2025
ICE gasoline (hybrid) - 2030
ICE diesel (hybrid) - 2025
ICE diesel (hybrid) - 2030
Plug-In Hybrid gasoline - 2025
Plug-In Hybrid gasoline - 2030
Plug-In Hybrid diesel - 2025
Plug-In Hybrid diesel - 2030
Range Extender gasoline - 2025
Range Extender gasoline - 2030
Range Extender diesel - 2025
Range Extender diesel - 2030
Battery Electric Vehicle - 2025
Battery Electric Vehicle - 2030


WTW specific GHG emissions in 2025 and 2030 -
TLC40
ICE vehicles
plug-in hybrids
range extender
battery electric vehicles
TTW
WTT from fuel
WTT from electricity
GHG emissions in g CO2eq/km
ICE gasoline (hybrid) - 2025
ICE gasoline (hybrid) - 2030
ICE diesel (hybrid) - 2025
ICE diesel (hybrid) - 2030
Plug-In Hybrid gasoline - 2025
Plug-In Hybrid gasoline - 2030
Plug-In Hybrid diesel - 2025
Plug-In Hybrid diesel - 2030
Range Extender gasoline - 2025
Range Extender gasoline - 2030
Range Extender diesel - 2025
Range Extender diesel - 2030
Battery Electric Vehicle - 2025
Battery Electric Vehicle - 2030

8.1.3 Considerations regarding embedded emissions

This sub-section provides some insight into existing LCA-studies. It should be noted however that these studies may not be directly comparable among them. Moreover, they are not necessarily consistent with the WTW analysis shown in the previous section

The interest in LCAs for objects as complex as automotive products has existed for many years but has only become more rigorous and robust in recent years. Manufacturers have been routinely producing LCAs of their products or key subassemblies for the past five years or so. More and more published material is available, but in spite of standardisation efforts e.g. under the ISO 14040 standard, there is still broad variability in the methodologies, assumptions and results available, mainly due to a scarcity in (verifiable) supply chain data and this often makes comparison impossible.

In parallel several academic studies (and reviews) have been published also comparing LCAs of conventional vs. alternative vehicles. These are described in more detail below.

While the purpose of most LCA/lifecycle impact assessment (LCIA)[73] studies is to enable comparison of alternative vehicle options across a range of different impact categories, we focus on climate impacts captured as normalised greenhouse gas (GHG) emissions. Note, however, that the conclusions may change when looking into other impact categories (e.g. acidification potential).

8.1.3.1 Relevance of embedded GHG emissions

Nordelöf et al. (2014)[74] analysed 79 papers on different types of LCA studies of electrified vehicles with the aim of identifying some robust conclusions on the environmental impacts of these vehicles. Despite the divergence in the analyses, some robust trends could be identified, noting that the predominant focus is on the current situation and not the future perspective. All studies agree that the WTW-related part currently dominates the total emissions of GHG both for ICEVs and for EVs. However, in relative terms, embedded emissions are of larger importance for electric vehicles both because of the drastic reductions in WTW emissions when using low-carbon electricity, and the need for components like the battery whose production is generally associated with elevated emissions.[75]

This is confirmed by a study supported by the German Federal Ministry of Transport and Digital Infrastructure[76], which bases the energy consumption values of EVs on the measured actual consumption of 735 vehicles that were operated in Germany with a total mileage of 5.2

[73] Lifecycle impact assessment, the step of the LCA where environmental impacts are calculated.

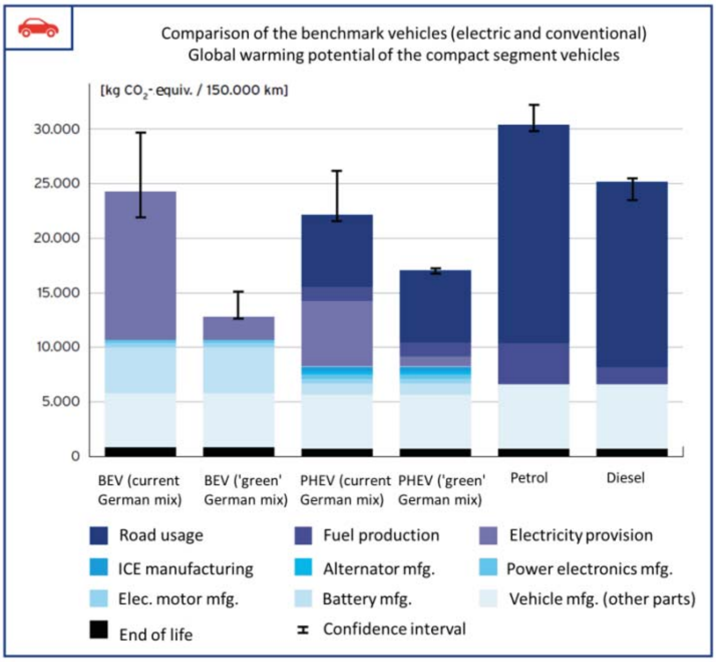
[74] Nordelöf, A., Messagie, M., Tillman, A.-M., Ljunggren Söderman, M., Van Mierlo, J.: Environmental impacts of hybrid, plug-in hybrid, and battery electric vehicles—what can we learn from life cycle assessment? Int J Life Cycle Assess (2014) 19:1866–1890; see also Erratum Int J Life Cycle Assess (2016) 21:134–135

[75] Obviously, the contribution of the embedded emissions to the overall life cycle GHG emissions per km largely depends on the lifetime mileages (decreasing importance with increasing lifetime mileage).

[76] BMVI (2016), publ. (German Federal Ministry of Transport and Digital Infrastructure): Bewertung der Praxistauglichkeit und Umweltwirkungen von Elektrofahrzeugen ("Final report: Assessment of the feasibility and environmental impacts of electric vehicles").

million km until 2015, primarily in fleets but also by private owners[77]. Figure 13, which is taken from this report, confirms that the equipment-related emissions become relatively more important in the case of EVs, in particular in the case of reduced WTW emissions due to a green electricity mix.

Figure 13: Life-cycle GHG emissions of different vehicles (compact class; Germany)



Source: adapted from BMVI, 2016; lifetime mileage assumed is 150,000 km

The largest source of equipment related emissions of BEV is the glider (Moro and Helmers, 2017, quoting Habermacher, 2011[78]), followed by the battery and the drivetrain. Considering that the glider is – to a large extent – common to the different vehicle type options, the manufacturing of the battery including the related production of the materials is the single most important source of GHG emissions, even though different studies vary concerning its share in the total emissions.

8.1.3.2 Battery related GHG emissions

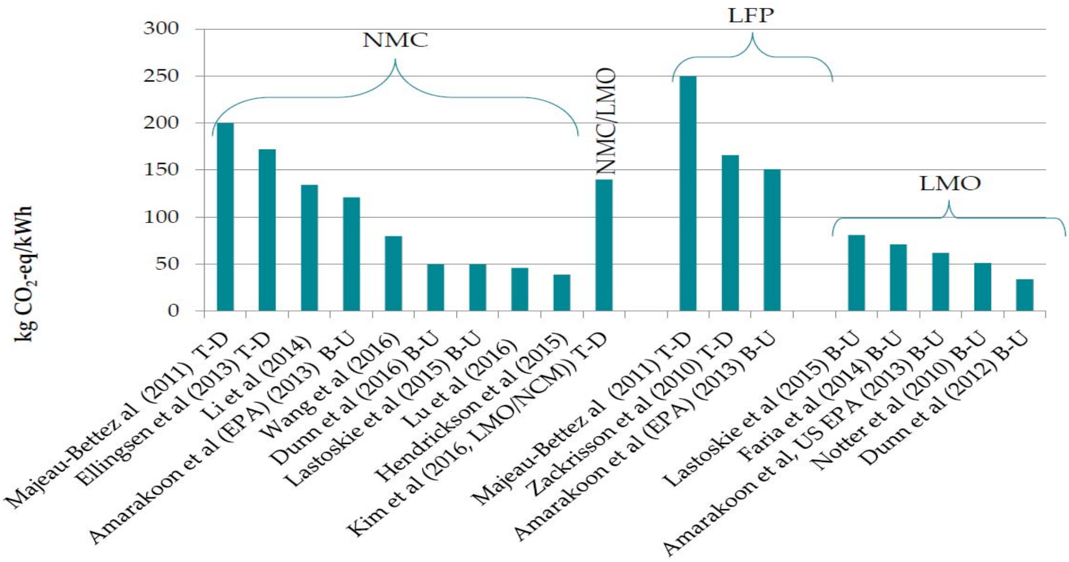
IVL recently performed an extensive literature review concerning the energy consumption and GHG emissions of vehicle battery production[79]. They found that the results among studies differ significantly, as shown in Figure 14.

[77] The measured average fuel consumption in the mini class was 4.73l/100km for gasoline, 3.72 l/100km for diesel and 13.9 kWh/100km for battery electric vehicles. In the compact class, the average consumption was 5.73l/100km gasoline, 4.3l/100km diesel and 14.9kWh/100 km BEV.

[78] Habermacher F (2011) Modeling material inventories and environmental impacts of electric passenger cars, MS-thesis, available at: http://www.empa.ch/plugin/template/empa/*/109104/—/l=1

[79] Romare, M., Dahllöf, L. (2017): The Life Cycle Energy Consumption and Greenhouse Gas Emissions from Lithium-Ion Batteries – A Study with Focus on Current Technology and Batteries for Light-duty Vehicles. IVL Swedish Environmental Research Institute.

Figure 14: Calculated greenhouse gas emissions for different LCA studies of lithium-ion batteries for light vehicles for the chemistries NMC, NMC/LMO, LFP and LMO

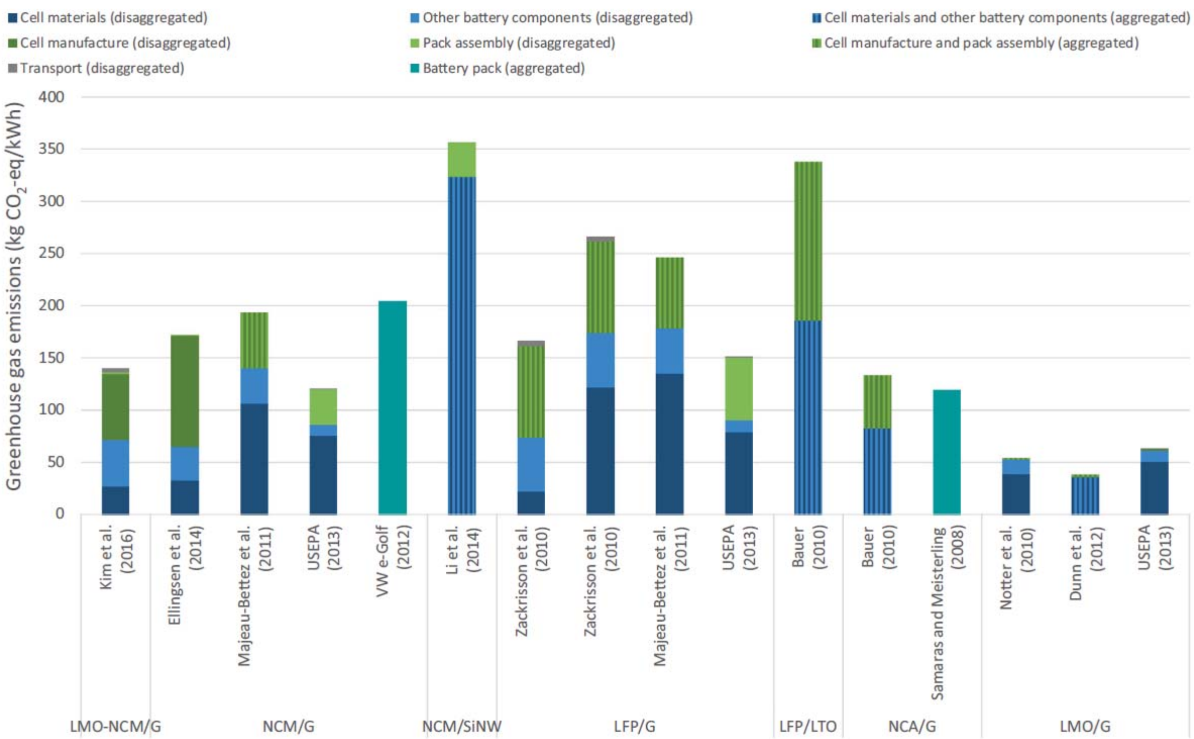


Notes: T-D=Top-down approach for manufacturing and B-U is Bottom-Up approach.

Source: IVL, 2017

Ellingsen et al. (2017) also carried out a review to assess the key assumptions and differences between 16 studies examining the lifecycle GHG emissions of batteries. They report up to a tenfold difference in the arising overall GHG emissions, as illustrated below regarding production emissions (cradle to gate):

Figure 15. Greenhouse gas emissions of battery production for different chemistries



Source: Ellingsen et al. (2017)

Both studies find that such differences can be explained by the different methodologies followed in the various papers, for example

- top down versus bottom-up[80] approaches,
- the scope (e.g. cooling system included)
- assumptions on production process steps and the energy sources used
- assumptions on cell materials and battery components
- the availability of primary versus secondary data.

Very few studies assessed the ulterior lifecycle steps, i.e. use phase and end-of-life, for GHG impacts; however, these are estimated to make a minor contribution to overall impacts. Overall, it is concluded (in line with Nordelöf et al., 2014)[81] that "most articles are non-transparent and there are usually information gaps in the goal and scope reporting" (IVL, 2017, p. 19).

Battery-production related GHG emissions seem to stem primarily from the battery (including cell) manufacturing, and only little from the mining and refining of the materials. In particular the production of the cathode requires large amounts of energy and is therefore highly GHG emitting, followed by anode and electrolyte production. Since the largest part of the energy used in the battery production is in the form of electricity, its carbon intensity largely influences the battery-related GHG emissions. A successful implementation of the EU's energy and climate objectives would therefore not only reduce the TTW-emissions of electric vehicles during their operation, but could further reduce the embedded emissions of the battery manufacturing process, assuming battery manufacturing takes place in the EU.

[80] The top-down studies start with manufacturing data from e.g. a plant, and allocate energy use to the processes based on information about the process. Bottom-up approaches on the other hand, collect data for each single activity in a facility. It is likely that the top-down data is more complete and includes energy use from auxiliary processes.

[81] Anders Nordelöf, Maarten Messagie, Anne-Marie Tillman, Maria Ljunggren Söderman, Joeri Van Mierlo: Environmental impacts of hybrid, plug-in hybrid, and battery electric vehicles—what can we learn from life cycle assessment? Int J Life Cycle Assess (2014) 19:1866–1890; see also Erratum Int J Life Cycle Assess (2016) 21:134–135

8.2 Target levels for cars (TLC) and vans (TLV)

8.2.1 Economic impacts

As explained in Section 6.1 of the Impact Assessment, the economic impacts for the "average" new vehicle were calculated using the cost output data of the PRIMES-TREMOVE model by averaging the contributions of the different size segments and powertrains, weighed according to their market penetration.

For this analysis, the following indicators have been used:

- Net economic savings from a societal perspective

  This parameter reflects the change in costs over the lifetime (15 years) of an "average" new vehicle without considering taxes and using a discount rate of 4%.

- Net savings from an end-user perspective, using two different indicators:
  - Total Cost of Ownership (TCO) over the vehicle lifetime

  This parameter reflects the change in costs over the lifetime (15 years) of an "average" new vehicle. In this case, given the end-user perspective, taxes are included and a discount rate of 11% (cars) or 9.5% (vans)[82] is used.

  - TCO for the first user, i.e. net savings during the first five years after registration:

  This parameter reflects the change in costs, during the first five years of use (i.e. the average time the first buyer is using the vehicle). Again, taxes are included and a discount rate of 11% (cars) or 9.5% (vans) is used. The calculation also takes account of the residual value of the vehicle (and the technology added) with depreciation.

8.2.1.1 Passenger cars (TLC)

This Section of the Annex provides an overview of the details of the calculations of the net savings and their components. The main results and the assessment are to be found in Section 6.3.2.2 of the Impact Assessment.

8.2.1.1.1 Net economic savings over the vehicle lifetime from a societal perspective

Table 10 shows the net savings (EUR per vehicle, expressed as the difference with the baseline) over the vehicle lifetime from a societal perspective for an average new passenger car registered in 2025 and in 2030 under the different TLC options.

The net savings observed are the result of differences in capital costs– which in this case are equal to manufacturing costs -, fuel cost savings and O&M costs.

Table 10: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/car)

2025 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	115	229	380	747	1,411	1,193

[82] Refer to Ref2016

O&M cost [2]	139	139	130	96	25	22
Fuel cost savings [3]	354	514	661	922	1,394	1,198
Net savings [3]-[1]-[2]	*100*	*147*	*152*	*78*	*-42*	*-17*

2030 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	419	679	1,020	1,812	1,861	2,752
O&M cost [2]	-62	-62	-96	-157	-168	-192
Fuel cost savings [3]	1,159	1,520	1,802	2,220	2,214	2,558
Net savings [3]-[1]-[2]	*802*	*902*	*878*	*565*	*521*	*-2*

8.2.1.1.2 TCO-15 years (vehicle lifetime)

Table 11 shows the TCO over 15 years (EUR per car) of an average new passenger car registered in 2025 and in 2030 under the different TLC options (expressed as the difference with the baseline), with "medium" costs assumption.

Table 11: TCO-15 years in 2025 and 2030 (EUR/car)

	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
2025	329	413	436	391	253	309
2030	1,227	1,374	1,359	1,012	1,012	389

8.2.1.1.3 TCO-first user (5 years)

Table 12 shows the net savings (EUR per car) from a first end-user perspective for an average new passenger car registered in 2025 and in 2030 under the different TLC options (expressed as the difference with the baseline).

The net savings observed are the result of differences in capital costs, fuel cost savings and O&M costs.

Table 12: TCO-first user (5 years) in 2025 and 2030 (EUR/car) for different TLC options

2025 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	90	179	297	585	1,104	934
O&M cost [2]	58	58	54	40	10	9
Fuel cost savings [3]	348	482	614	866	1,286	1,138
Net savings	*200*	*245*	*263*	*241*	*171*	*195*

[3]-[1]-[2]						

2030 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	328	532	799	1,419	1,456	2,154
O&M cost [2]	-26	-26	-40	-66	-71	-82
Fuel cost savings [3]	1,025	1,323	1,576	1,992	2,012	2,354
Net savings [3]-[1]-[2]	*723*	*817*	*818*	*639*	*627*	*282*

8.2.1.1.4 Sensitivity – economic impacts under *varying cost assumptions*

As explained in Section 6.1 of the Impact Assessment, for the purpose of analysing the sensitivity of cost assumptions apart from the "medium" costs, a number of cost-curves were developed illustrating the impact of low and high technology cost estimates. These different cost estimates were calculated using a methodological approach developed and refined in consultation with stakeholders and a statistical model to assess the uncertainty in the future cost projections. The "medium" cost case represents the most likely scenario resulting from significant future technology deployment to meet post-2020 CO_2 targets.

The tables below summarise the net economic savings for a range of TLC options, with technology costs varying as follows:

- "High": High costs for EV and ICEV
- "High ICE": Medium costs for EV, High Costs for ICEV
- "Medium": 'default' case with medium cost assumptions for all technologies, as applied in Section 8.2.1.1;
- "LxEV": Low costs for EV, Medium Costs for ICEV;
- "Low": Low costs for EV and ICEV

The tables document to what extent the capital costs, O&M costs and fuel savings, as well as the resulting net savings vary with differing technology cost assumptions.

Results are presented for the savings over a vehicle lifetime from a societal perspective, for a TOC-15-years end-user perspective (only showing the net savings in this case) and from a TCO-first user (5 years) perspective.

Net savings increase as technology costs are getting lower due to a combination of lower capital costs and higher fuel savings (as the share of alternative powertrains, incl. EV, increases).

Across the different cost assumptions assessed, the highest net savings are usually found when using "Low" costs.

Table 13: Sensitivity - Net economic savings from a societal perspective in 2025 and 2030 under different cost assumptions for a range of TLC options (EUR/car) (N/A: data are not available)

TLC20 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	593	380	115	N/A	N/A
O&M cost [2]	158	147	139	N/A	N/A
Fuel cost savings [3]	412	321	354	N/A	N/A
Net savings [3]-[1]-[2]	*-338*	*-205*	*100*	*N/A*	*N/A*

TLC20 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,000	689	419	N/A	N/A
O&M cost [2]	-31	-45	-62	N/A	N/A
Fuel cost savings [3]	1,260	1,127	1,159	N/A	N/A
Net savings [3]-[1]-[2]	*290*	*483*	*802*	*N/A*	*N/A*

TLC25 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	769	538	229	91	-110
O&M cost [2]	158	147	139	116	106
Fuel cost savings [3]	587	495	514	396	407
Net savings [3]-[1]-[2]	*-340*	*-190*	*147*	*189*	*412*

TLC25 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,416	1,034	679	366	166
O&M cost [2]	-31	-45	-62	-100	-117
Fuel cost savings [3]	1,621	1,486	1,520	1,323	1,347
Net savings [3]-[1]-[2]	*236*	*498*	*902*	*1,057*	*1,297*

TLC30 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	989	716	380	215	-19
O&M cost [2]	131	133	130	116	106
Fuel cost savings [3]	691	627	661	578	592
Net savings [3]-[1]-[2]	*-429*	*-222*	*152*	*247*	*505*

TLC30 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***

Capital cost [1]	1,863	1,415	1,020	654	386
O&M cost [2]	-86	-80	-96	-100	-117
Fuel cost savings [3]	1,829	1,747	1,802	1,687	1,717
Net savings [3]-[1]-[2]	*51*	*412*	*878*	*1,133*	*1,448*

TLC40 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,863	1,415	1,020	654	386
O&M cost [2]	-86	-80	-96	-100	-117
Fuel cost savings [3]	1,829	1,747	1,802	1,687	1,717
Net savings [3]-[1]-[2]	*51*	*412*	*878*	*1,133*	*1,448*

TLC40 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	2,807	2,241	1,812	1,310	988
O&M cost [2]	-133	-133	-157	-153	-185
Fuel cost savings [3]	2,168	2,156	2,220	2,151	2,213
Net savings [3]-[1]-[2]	*-506*	*48*	*565*	*994*	*1,410*

Table 14: Sensitivity - TCO-lifetime (15 years) in 2025 and 2030 under different cost assumptions (net savings in EUR/car) for a range of TLC options

TLC20	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	-303	-84	329	N/A	N/A
2030	479	798	1,227	N/A	N/A

TLC25	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	-297	-53	413	507	815
2030	411	829	1,374	1,660	1,987

TLC30	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	-393	-75	439	599	952
2030	195	738	1,359	1,770	2,187

TLC40	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	-674	-173	391	652	1,084

2030	-441	342	1,012	1,663	2,221

Table 15 Sensitivity - TCO-first end user (5 years) in 2025 and 2030 under different cost assumptions (net savings in EUR/car)

TLC20 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	464	297	90	N/A	N/A
O&M cost [2]	67	63	58	N/A	N/A
Fuel cost savings [3]	379	326	348	N/A	N/A
Net savings [3]-[1]-[2]	*-152*	*-34*	*200*	*N/A*	*N/A*

TLC20 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	783	539	328	N/A	N/A
O&M cost [2]	-13	-19	-26	N/A	N/A
Fuel cost savings [3]	1,083	1,006	1,025	N/A	N/A
Net savings [3]-[1]-[2]	*314*	*486*	*723*	*N/A*	*N/A*

TLC25 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	602	560	179	71	-86
O&M cost [2]	67	57	58	50	45
Fuel cost savings [3]	525	594	482	417	424
Net savings [3]-[1]-[2]	*-144*	*-22*	*245*	*297*	*466*

TLC25 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,108	809	532	287	130
O&M cost [2]	-13	-19	-26	-43	-50
Fuel cost savings [3]	1,381	1,302	1,323	1,213	1,229
Net savings [3]-[1]-[2]	*285*	*513*	*817*	*969*	*1,148*

TLC30 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	774	872	297	168	-15
O&M cost [2]	56	41	54	50	45
Fuel cost savings [3]	631	837	614	569	579

Net savings [3]-[1]-[2]	*-199*	*-75*	*263*	*352*	*549*

TLC30 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,458	1,107	799	512	302
O&M cost [2]	-36	-34	-40	-43	-50
Fuel cost savings [3]	1,589	1,542	1,576	1,513	1,534
Net savings [3]-[1]-[2]	*167*	*469*	*818*	*1,044*	*1,282*

TLC40 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,150	560	585	411	190
O&M cost [2]	41	57	40	39	39
Fuel cost savings [3]	835	594	866	836	855
Net savings [3]-[1]-[2]	*-355*	*-22*	*241*	*386*	*627*

TLC40 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	2,197	1,754	1,419	1,025	773
O&M cost [2]	-57	-57	-66	-65	-79
Fuel cost savings [3]	1,957	1,951	1,992	1,959	1,999
Net savings [3]-[1]-[2]	*-184*	*254*	*639*	*998*	*1,304*

8.2.1.1.5 Sensitivity – economic impacts *with varying international oil price*

Section 6.3.2.2 of the Impact Assessment shows the net economic savings (from different perspectives) from new CO_2 target levels, resulting from an higher increase of the fuel savings with respect to the capital costs in case the fleet is composed by more efficient vehicles. The international fuel price projections used for the calculation of the fuel savings are those used in the Reference Scenario 2016[83], 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 in 2030. The new projected fuel price used for this sensitivity is about 25% lower than in the assumptions used for the Reference Scenario 2016.

The economic analysis is repeated with the lower international fuel prices, both in the baseline and for selected options for the target levels: TLC20, TLC25, TLC30, TLC40.

Table 16 and Table 17 show the results for the net economic savings for passengers cars from a societal perspective and for the TCO-15 years, respectively. Even with the lower oil prices,

[83] https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

CO_2 targets continue to have a positive economic effect, with fuel savings continuing to overweight increased capital expenditures for more efficient vehicles.

Table 16: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/car) under different TLC options in case of a lower international fuel price

	TLC20	**TLC25**	**TLC30**	**TLC40**
2025	13	31	4	-135
2030	570	612	525	96

Table 17: TCO-lifetime (15 years) in 2025 and 2030 under different cost assumptions (net savings in EUR/car) for a range of TLC options in case of a lower international fuel price

	TLC20	**TLC25**	**TLC30**	**TLC40**
2025	253	304	301	195
2030	1,010	1,106	1,035	590

8.2.1.2 Light commercial vehicles (TLV)

8.2.1.2.1 Net economic savings over the vehicle lifetime from a societal perspective

This Section of the Annex provides an overview of the details of the calculations of the net savings and their components. The main results and the assessment are to be found in Section 6.3.2.2 of the Impact Assessment.

Table 18 shows the net savings over the vehicle lifetime from a societal perspective for an average new van registered in 2025 and in 2030 under the different TLV options (expressed as the difference with the baseline).

The net savings observed are the result of differences in capital costs– which in this case are equal to manufacturing costs -, fuel cost savings and O&M costs.

Table 18: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/van)

2025	TLV20	TLV25	TLV30	TLV40	TLV_EP 40	TLV_EP 50
Capital cost [1]	232	355	393	877	1,251	1,469
O&M cost [2]	-40	-52	-58	-106	-91	-119
Fuel cost savings [3]	1,002	1,265	1,685	2,061	2,529	2,316
Net savings [3-1-2]	*810*	*962*	*1,350*	*1,290*	*1,369*	*967*

2030	TLV20	TLV25	TLV30	TLV40	TLV_EP 40	TLV_EP 50
Capital cost [1]	426	620	891	1,582	1,415	2,439
O&M cost [2]	-50	-55	-75	-142	-141	-239
Fuel cost savings [3]	2,063	2,600	3,064	3,827	3,341	4,261
Net savings [3-1-2]	*1,687*	*2,036*	*2,247*	*2,386*	*2,067*	*2,060*

8.2.1.2.2 TCO-15 years (vehicle lifetime)

Table 19 shows the TCO over 15 years (EUR per car) of an average new passenger car registered in 2025 and in 2030 under the different TLC options (expressed as the difference with the baseline).

Table 19: TCO-15 years in 2025 and 2030 (EUR/van)

	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
2025	1,382	1,680	2,255	2,466	2,520	2,390
2030	2,764	3,377	3,825	4,390	3,211	4,403

8.2.1.2.3 TCO-first user (5 years)

Table 20 shows the net savings from a first end-user perspective for an average new van registered in 2025 and in 2030 under the different TLV options (expressed as the difference with the baseline).

Table 20: TCO-first user (5 years) in 2025 and 2030 (EUR/van)

2025 (EUR/van)	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Capital cost [1]	144	221	244	545	778	913
O&M cost [2]	-17	-23	-25	-46	-40	-52
Fuel cost savings [3]	1,016	1,281	1,662	2,115	2,614	2,485
Net savings [3]-[1]-[2]	*889*	*1,083*	*1,443*	*1,616*	*1,876*	*1,624*

2030 (EUR/van)	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Capital cost [1]	265	386	554	984	879	1,516
O&M cost [2]	-22	-24	-33	-62	-61	-104
Fuel cost savings [3]	2,026	2,546	3,013	3,833	3,382	4,412
Net savings [3]-[1]-[2]	*1,783*	*2,184*	*2,492*	*2,912*	*2,564*	*3,000*

8.2.1.2.4 Sensitivity – economic impacts under *varying cost assumptions*

As explained in Section 6.1 of the Impact Assessment, for the purpose of analysing the sensitivity of cost assumptions apart from the "medium" costs, a number of cost-curves were developed illustrating the impact of low and high technology cost estimates. These different cost estimates were calculated using a methodological approach developed and refined in consultation with stakeholders and a statistical model to assess the uncertainty in the future cost projections. The "medium" cost case represents the most likely scenario resulting from significant future technology deployment to meet post-2020 CO_2 targets.

The tables below summarise the net economic savings for a range of TLV options, with technology costs varying as follows:

- "High": High costs for EV and ICEV
- "High ICE": Medium costs for EV, High Costs for ICEV
- "Medium": 'default' case with medium cost assumptions for all technologies, as applied in Section 8.2.1.1;
- "LxEV": Low costs for EV, Medium Costs for ICEV;
- "Low": Low costs for EV and ICEV

The tables document to what extent the capital costs, O&M costs and fuel savings, as well as the resulting net savings vary with differing technology cost assumptions.

Results are presented for the savings over a vehicle lifetime from a societal perspective, for a TOC-15-years end-user perspective (only showing the net savings in this case) and from a TCO-first user (5 years) perspective.

Net savings increase as technology costs are getting lower due to a combination of lower capital costs and higher fuel savings (as the share of alternative powertrains, incl. EV, increases).

Across the different cost assumptions assessed, the highest net savings are usually found when using "Low" costs.

Table 21: Sensitivity - Net economic savings from a societal perspective in 2025 and 2030 under different cost assumptions for a range of TLV options (EUR/van) (N/A: data are not available)

TLV20 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	565	393	232	N/A	N/A
O&M cost [2]	-32	-45	-40	N/A	N/A
Fuel cost savings [3]	1,067	959	1,002	N/A	N/A
Net savings [3]-[1]-[2]	*534*	*611*	*810*	*N/A*	*N/A*

TLV20 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	873	596	426	N/A	N/A
O&M cost [2]	-34	-56	-50	N/A	N/A

Fuel cost savings [3]	2,156	2,020	2,063	N/A	N/A
Net savings [3]-[1]-[2]	*1,316*	*1,480*	*1,687*	*N/A*	*N/A*

TLV25 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	765	545	355	240	121
O&M cost [2]	-55	-60	-52	-63	-58
Fuel cost savings [3]	1,313	1,212	1,265	1,155	1,191
Net savings [3]-[1]-[2]	*602*	*727*	*962*	*979*	*1,127*

TLV25 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,194	843	620	358	235
O&M cost [2]	-47	-67	-55	-83	-77
Fuel cost savings [3]	2,642	2,537	2,600	2,438	2,470
Net savings [3]-[1]-[2]	*1,495*	*1,760*	*2,036*	*2,163*	*2,312*

TLV40 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,561	1,132	877	669	370
O&M cost [2]	-110	-110	-106	-112	-59
Fuel cost savings [3]	1,954	1,964	2,061	1,973	2,250
Net savings [3]-[1]-[2]	*503*	*942*	*1,290*	*1,416*	*1,938*

TLV40 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	2,553	1,863	1,582	1,091	814
O&M cost [2]	-154	-154	-142	-161	-79
Fuel cost savings [3]	3,715	3,742	3,827	3,738	4,301
Net savings [3]-[1]-[2]	*1,317*	*2,033*	*2,386*	*2,808*	*3,566*

Table 22: Sensitivity - TCO-lifetime (15 years) in 2025 and 2030 under different cost assumptions (net savings in EUR/van) for a range of TLV options]

TLV20	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	1,079	1,165	1,382	N/A	N/A
2030	2,361	2,529	2,764	N/A	N/A

TLV25	***High***	***High ICE***	***Medium***	***LxEV***	***Low***

2025	1,280	1,418	1,680	1,706	1,867
2030	2,777	3,064	3,377	3,528	3,676

TLV40	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
2025	1,586	2,074	2,466	2,627	3,209
2030	3,198	3,995	4,390	4,902	5,785

Table 23 Sensitivity - TCO-first end user (5 years) in 2025 and 2030 under different cost assumptions (net savings in EUR/van)

TLV20 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	351	244	144	N/A	N/A
O&M cost [2]	-14	-20	-17	N/A	N/A
Fuel cost savings [3]	1,056	988	1,016	N/A	N/A
Net savings [3]-[1]-[2]	*719*	*763*	*889*	*N/A*	*N/A*

TLV20 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	543	370	265	N/A	N/A
O&M cost [2]	-15	-24	-22	N/A	N/A
Fuel cost savings [3]	2,087	1,994	2,026	N/A	N/A
Net savings [3]-[1]-[2]	*1,559*	*1,648*	*1,783*	*N/A*	*N/A*

TLV25 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	476	339	221	149	75
O&M cost [2]	-24	-26	-23	-28	-25
Fuel cost savings [3]	1,310	1,247	1,281	1,214	1,237
Net savings [3]-[1]-[2]	*859*	*934*	*1,083*	*1,093*	*1,186*

TLV25 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	742	524	386	223	146
O&M cost [2]	-20	-29	-24	-36	-33
Fuel cost savings [3]	2,570	2,500	2,546	2,439	2,460
Net savings [3]-[1]-[2]	*1,848*	*2,005*	*2,184*	*2,253*	*2,347*

TLV40 - 2025 (EUR/van)	*High*	*High ICE*	*Medium*	*LxEV*	*Low*
Capital cost [1]	970	704	545	416	230
O&M cost [2]	-48	-48	-46	-49	-26
Fuel cost savings [3]	2,042	2,048	2,115	2,065	2,249
Net savings [3]-[1]-[2]	*1,119*	*1,393*	*1,616*	*1,698*	*2,044*

TLV40 - 2030 (EUR/van)	*High*	*High ICE*	*Medium*	*LxEV*	*Low*
Capital cost [1]	1,587	1,158	984	678	506
O&M cost [2]	-67	-67	-62	-70	-34
Fuel cost savings [3]	3,753	3,774	3,833	3,783	4,184
Net savings [3]-[1]-[2]	*2,234*	*2,684*	*2,912*	*3,175*	*3,713*

8.2.1.2.5 Sensitivity – economic impacts *with varying international oil price*

Similarly as for cars, as a sensitivity analysis, the changes to the net economic savings in case of different international fuel price projections were assessed, using a scenario assuming an reduction of the oil prices of around 25% in 2030 with respect to the price in 2030 of the Reference Scenario 2016. " (see Section 8.2.1.1.5).

The economic analysis is repeated with the lower international fuel prices, both in the baseline and for selected options for the target levels TLV20, TLV25, TLV40.

Table 16 and Table 17 show the results for the net economic savings for passengers cars from a societal perspective and for the TCO-15 years, respectively. Even with the lower oil prices, CO_2 targets continue to have a positive economic effect, with fuel savings continuing to overweight increased capital expenditures for more efficient vehicles.

Table 24: Net economic savings over the vehicle lifetime from a societal perspective in 2025 and 2030 (EUR/van) under different TLV options in case of a lower international fuel price

	TLV20	TLV25	TLV40
2025	588	682	814
2030	1,281	1,527	1,546

Table 25: TCO-15 years (vehicle lifetime) in 2025 and 2030 under different cost assumptions (net savings in EUR/car) for a range of TLV options in case of a lower international fuel price

	TLV20	TLV25	TLV40
2025	1,180	1,422	2,027
2030	2,368	2,881	3,601

8.2.2 Social Impacts

8.2.2.1 TCO for second user - passenger cars (TLC)

The detailed results of the analysis of the TCO for the second car user are summarised in Table 26.

Table 26: TCO-second user in 2025 and 2030 (EUR/car)

2025 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	43	86	143	282	532	450
O&M cost [2]	58	58	54	40	10	9
Fuel cost savings [3]	302	416	527	742	1,096	976
Net savings [3]-[1]-[2]	*201*	*272*	*329*	*420*	*553*	*516*

2030 (EUR/car)	TLC20	TLC25	TLC30	TLC40	TLC_EP40	TLC_EP50
Capital cost [1]	158	256	385	684	702	1,039
O&M cost [2]	-26	-26	-40	-66	-71	-82
Fuel cost savings [3]	841	1,083	1,292	1,640	1,659	1,953
Net savings [3]-[1]-[2]	*708*	*853*	*947*	*1,022*	*1,028*	*996*

8.2.2.2 Sensitivity - TCO for second user - passenger cars (TLC) with varying technology cost assumptions

Table 27 summarises the detailed results of the sensitivity analysis of the TCO for the second car user for various TLC options and with different technology cost assumptions.

Table 27: Sensitivity - TCO-second end user (years 6-10) for passenger cars in 2025 and 2030 under different cost assumptions (net savings in EUR/car)

TLC20 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	224	143	43	N/A	N/A
O&M cost [2]	67	63	58	N/A	N/A
Fuel cost savings [3]	324	283	302	N/A	N/A
Net savings [3]-[1]-[2]	*33*	*77*	*201*	*N/A*	*N/A*

TLC20 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	377	260	158	N/A	N/A
O&M cost [2]	-13	-19	-26	N/A	N/A
Fuel cost savings [3]	882	823	841	N/A	N/A

Net savings [3]-[1]-[2]	*518*	*582*	*708*	*N/A*	*N/A*

TLC25 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	290	203	86	34	-42
O&M cost [2]	67	63	58	50	45
Fuel cost savings [3]	445	404	416	366	373
Net savings [3]-[1]-[2]	*88*	*139*	*272*	*282*	*370*

TLC25 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	534	390	256	138	63
O&M cost [2]	-13	-19	-26	-43	-50
Fuel cost savings [3]	1,125	1,065	1,083	998	1,011
Net savings [3]-[1]-[2]	*603*	*694*	*853*	*903*	*997*

TLC30 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	373	270	143	81	-7
O&M cost [2]	56	57	54	50	45
Fuel cost savings [3]	538	509	527	492	500
Net savings [3]-[1]-[2]	*109*	*182*	*329*	*362*	*463*

TLC30 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	703	534	385	247	146
O&M cost [2]	-36	-34	-40	-43	-50
Fuel cost savings [3]	1,300	1,264	1,292	1,243	1,258
Net savings [3]-[1]-[2]	*634*	*764*	*947*	*1,039*	*1,162*

TLC40 - 2025 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	555	420	282	198	91
O&M cost [2]	41	41	40	39	39
Fuel cost savings [3]	717	718	742	718	734
Net savings [3]-[1]-[2]	*122*	*257*	*420*	*481*	*604*

TLC40 - 2030 (EUR/car)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	1,059	846	684	494	373

O&M cost [2]	-57	-57	-66	-65	-79
Fuel cost savings [3]	1,611	1,607	1,640	1,613	1,644
Net savings [3]-[1]-[2]	*609*	*818*	*1,022*	*1,183*	*1,350*

8.2.2.3 TCO for second user - vans (TLV)

The detailed results of the analysis of the TCO for the second van user are summarised in Table 28.

Table 28: Table: TCO-second user in 2025 and 2030 (EUR/van)

2025 (EUR/van)	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Capital cost [1]	69	106	118	263	375	440
O&M cost [2]	-17	-23	-25	-46	-40	-52
Fuel cost savings [3]	707	893	1,155	1,475	1,824	1,739
Net savings [3]-[1]-[2]	*655*	*809*	*1,063*	*1,258*	*1,489*	*1,351*

2030 (EUR/van)	TLV20	TLV25	TLV30	TLV40	TLV_EP40	TLV_EP50
Capital cost [1]	128	186	267	474	424	731
O&M cost [2]	-22	-24	-33	-62	-61	-104
Fuel cost savings [3]	1,388	1,743	2,064	2,629	2,321	3,032
Net savings [3]-[1]-[2]	*1,282*	*1,582*	*1,830*	*2,217*	*1,958*	*2,405*

8.2.2.4 TCO for second user - vans (TLV) and sensitivity regarding technology cost assumptions

Table 29 summarises the detailed results of the sensitivity analysis of the TCO for the second user of vans for various TLV options and with different technology cost assumptions.

Table 29: Sensitivity - TCO-second end user (years 6-10) for vans in 2025 and 2030 under different cost assumptions (net savings in EUR/van)

TLV20 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	169	118	69	N/A	N/A
O&M cost [2]	-14	-20	-17	N/A	N/A
Fuel cost savings [3]	734	689	707	N/A	N/A
Net savings [3]-[1]-[2]	*579*	*591*	*655*	*N/A*	*N/A*

TLV20 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***

Capital cost [1]	262	179	128	N/A	N/A
O&M cost [2]	-15	-24	-22	N/A	N/A
Fuel cost savings [3]	1,428	1,366	1,388	N/A	N/A
Net savings [3]-[1]-[2]	*1,181*	*1,212*	*1,282*	*N/A*	*N/A*

TLV25 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	229	163	106	72	36
O&M cost [2]	-24	-26	-23	-28	-25
Fuel cost savings [3]	912	869	893	848	863
Net savings [3]-[1]-[2]	*706*	*732*	*809*	*804*	*852*

TLV25 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	358	253	186	107	70
O&M cost [2]	-20	-29	-24	-36	-33
Fuel cost savings [3]	1,759	1,713	1,743	1,673	1,687
Net savings [3]-[1]-[2]	*1,422*	*1,489*	*1,582*	*1,602*	*1,650*

TLV40 - 2025 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	468	339	263	200	111
O&M cost [2]	-48	-48	-46	-49	-26
Fuel cost savings [3]	1,425	1,430	1,475	1,442	1,565
Net savings [3]-[1]-[2]	*1,006*	*1,139*	*1,258*	*1,290*	*1,479*

TLV40 - 2030 (EUR/van)	***High***	***High ICE***	***Medium***	***LxEV***	***Low***
Capital cost [1]	765	558	474	327	244
O&M cost [2]	-67	-67	-62	-70	-34
Fuel cost savings [3]	2,575	2,589	2,629	2,596	2,865
Net savings [3]-[1]-[2]	*1,877*	*2,098*	*2,217*	*2,339*	*2,655*

8.3 Distribution of effort (DOE): additional information regarding impacts on competition between manufacturers

The analysis presented in Section 6.4 of the Impact Assessment has looked at how manufacturing costs of different types of manufacturers may change across different policy options considered for distributing the efforts. It used both an absolute price indicator and a relative one (cost increase relative to the average price of the vehicles).

This Section presents additional modelling results, complementing those presented in the main text of the Impact Assessment.

Passenger cars

The two figures below show the main results of the analysis for passenger cars in case of an EU-wide fleet CO_2 target in 2025 and 2030 under option TLC25.

Figure 16 shows the cost increase per vehicle (EUR/car), while in Figure 17 these costs are related to the vehicle price (cost increase in % of car price).

Figure 16: Additional manufacturing costs (EUR/car) for categories of passenger car manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLC25

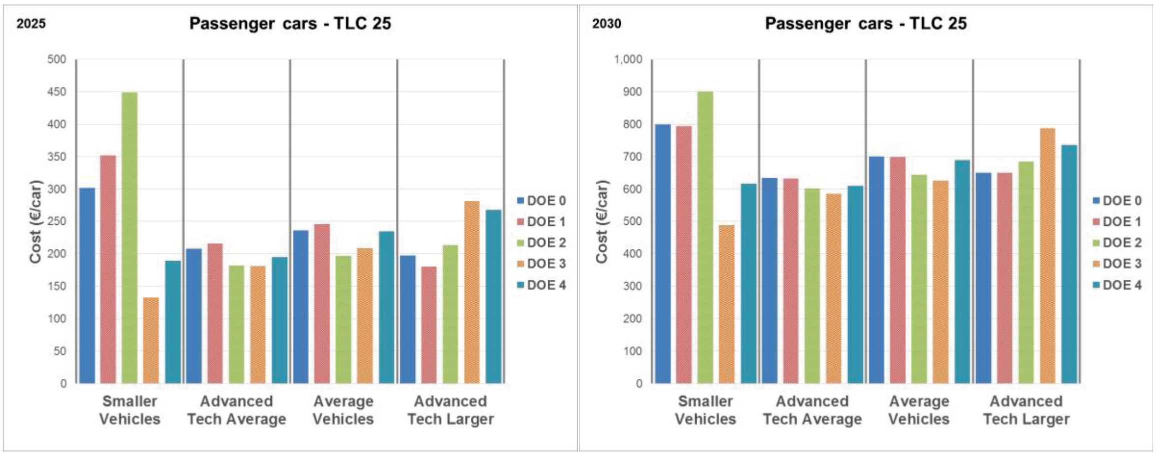
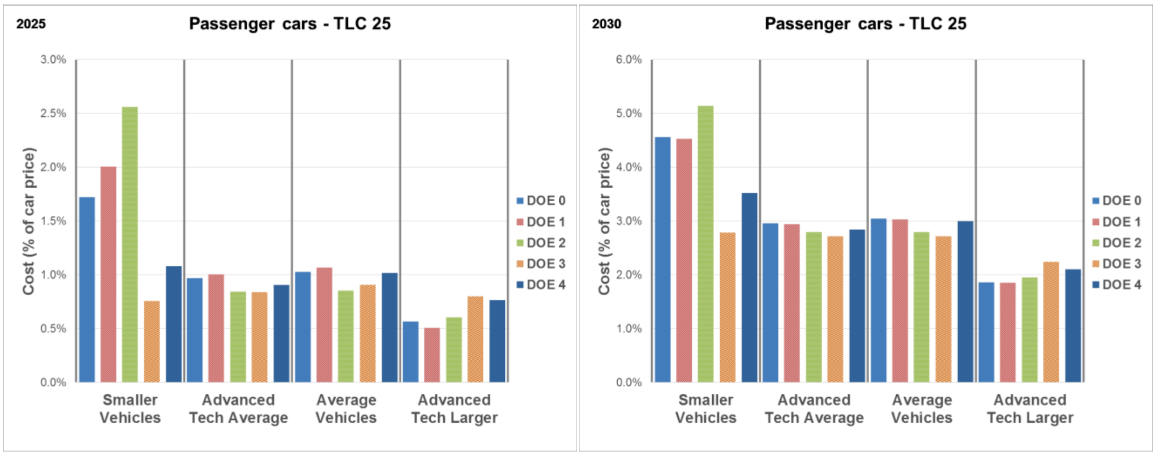


Figure 17: Additional manufacturing costs relative to vehicle price (% of car price) for categories of passenger car manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLC25



Vans

The two figures below show the main results for vans with EU-wide fleet CO_2 targets in 2025 and 2030 as under option TLV25. Figure 18 shows the absolute manufacturing cost increase (EUR/van), while in Figure 19 these costs are related to the vehicle price (cost increase in % of van price).

Figure 18: Additional manufacturing costs (EUR/van) for categories of van manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLV25

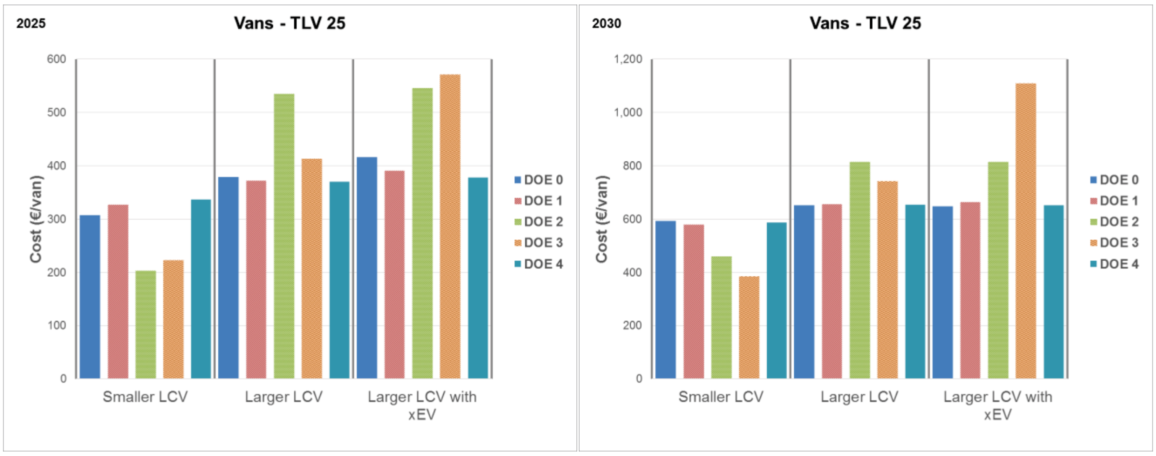
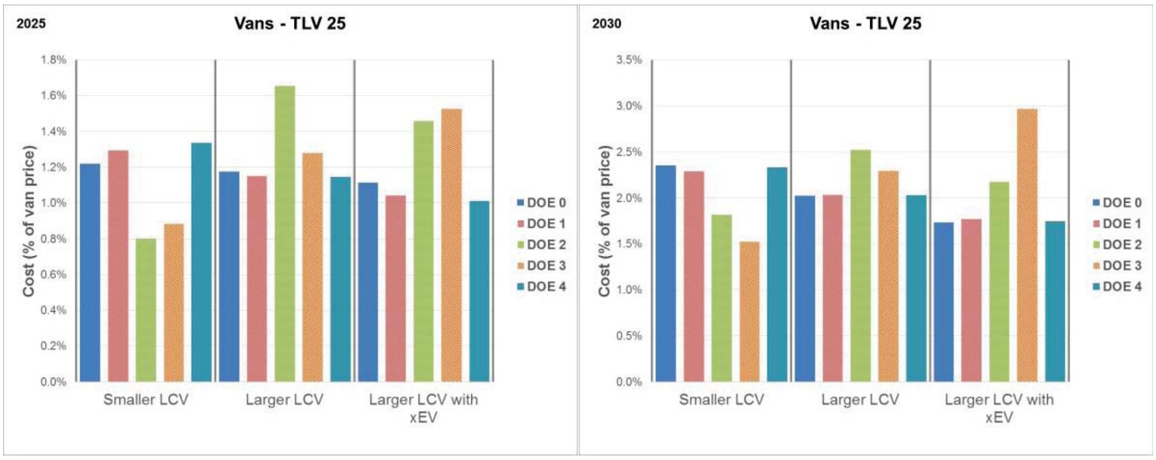


Figure 19: Additional manufacturing costs relative to vehicle price (% of van price) for categories of van manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLV25



8.4 ZEV/ LEV incentives

8.4.1 Passenger cars: assessment of options with additional incentives for low-emission vehicles: economic and social impacts

Table 30 provides a detailed overview of the net savings achieved under the different LEV incentives options using the different indicators used in the economic and social analysis.

Table 30: Detailed overview of the net savings in EUR/car under different LEV incentive options (LEV definitions, CO_2 targets and LEV mandate/benchmark levels) for 2025 and 2030 passenger cars using several economic (societal perspective, TCO-first user) and social (TCO-second user) impact indicators

TLC20 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	115	-241	-273
O&M cost [2]	1	136	176
Fuel cost savings [3]	354	143	-71
Net savings [3]-[1]-[2]	*100*	*248*	*27*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	90	-189	-214
O&M cost [2]	58	57	74
Fuel cost savings [3]	348	228	116
Net savings [3]-[1]-[2]	*200*	*360*	*257*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	43	-91	-103
O&M cost [2]	58	57	74
Fuel cost savings [3]	302	198	94
Net savings [3]-[1]-[2]	*201*	*232*	*124*

TLC20 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	419	-116	-139
O&M cost [2]	-62	-129	-120
Fuel cost savings [3]	1,159	739	595
Net savings [3]-[1]-[2]	*802*	*984*	*854*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	328	-91	-109
O&M cost [2]	-26	-54	-50
Fuel cost savings [3]	1,025	789	719
Net savings [3]-[1]-[2]	*723*	*934*	*878*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	158	-44	-53
O&M cost [2]	-26	-54	-50
Fuel cost savings [3]	841	648	589
Net savings [3]-[1]-[2]	*708*	*746*	*692*

TLC25 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	229	-150	-194
O&M cost [2]	1	138	168
Fuel cost savings [3]	514	298	97
Net savings [3]-[1]-[2]	*149*	*310*	*123*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	179	-117	-152
O&M cost [2]	58	59	72
Fuel cost savings [3]	482	365	259
Net savings [3]-[1]-[2]	*245*	*424*	*339*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	86	-57	-73
O&M cost [2]	58	59	72
Fuel cost savings [3]	416	310	213
Net savings [3]-[1]-[2]	*272*	*308*	*215*

TLC25 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	682	37	-3
O&M cost [2]	-60	-131	-126
Fuel cost savings [3]	1,521	1,094	952
Net savings [3]-[1]-[2]	*899*	*1,188*	*1,080*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	533	29	-2
O&M cost [2]	-26	-56	-53
Fuel cost savings [3]	1,325	1,085	1,015
Net savings [3]-[1]-[2]	*817*	*1,111*	*1,070*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	257	14	-1
O&M cost [2]	-26	-56	-53
Fuel cost savings [3]	1,084	889	830
Net savings [3]-[1]-[2]	*853*	*931*	*884*

TLC30 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	380	-43	-101
O&M cost [2]	1	144	166
Fuel cost savings [3]	661	462	274
Net savings [3]-[1]-[2]	*152*	*361*	*209*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	297	-34	-79
O&M cost [2]	54	60	70
Fuel cost savings [3]	614	510	408
Net savings [3]-[1]-[2]	*263*	*483*	*417*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	143	-16	-38
O&M cost [2]	54	60	70
Fuel cost savings [3]	527	429	338
Net savings [3]-[1]-[2]	*329*	*385*	*306*

TLC30 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,020	249	181
O&M cost [2]	-96	-138	-136
Fuel cost savings [3]	1,802	1,466	1,314
Net savings [3]-[1]-[2]	*878*	*1,355*	*1,269*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	799	195	142
O&M cost [2]	-40	-58	-57
Fuel cost savings [3]	1,576	1,393	1,315
Net savings [3]-[1]-[2]	*818*	*1,256*	*1,230*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	385	94	68
O&M cost [2]	-40	-58	-57
Fuel cost savings [3]	1,292	1,138	1,074
Net savings [3]-[1]-[2]	*947*	*1,101*	*1,062*

TLC40 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	747	179	116
O&M cost [2]	1	107	122
Fuel cost savings [3]	922	799	701
Net savings [3]-[1]-[2]	*78*	*513*	*462*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	585	140	91
O&M cost [2]	40	45	51
Fuel cost savings [3]	866	808	756
Net savings [3]-[1]-[2]	*241*	*623*	*615*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	282	68	44
O&M cost [2]	40	45	51
Fuel cost savings [3]	742	677	630
Net savings [3]-[1]-[2]	*420*	*565*	*535*

TLC40 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,812	794	730
O&M cost [2]	-157	-169	-187
Fuel cost savings [3]	2,220	2,045	1,999
Net savings [3]-[1]-[2]	*565*	*1,420*	*1,456*

LEVD_ZEV	***TCO-first user (5 years) (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,419	621	571
O&M cost [2]	-66	-71	-78
Fuel cost savings [3]	1,992	1,906	1,887
Net savings [3]-[1]-[2]	*639*	*1,356*	*1,395*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	684	299	275
O&M cost [2]	-66	-71	-78
Fuel cost savings [3]	1,640	1,557	1,539
Net savings [3]-[1]-[2]	*1,022*	*1,329*	*1,342*

TLC20 – 2025 (LEVD_25)

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	115	-233	-229
O&M cost [2]	1	170	207
Fuel cost savings [3]	354	42	-153
Net savings [3]-[1]-[2]	*100*	*106*	*-131*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	90	-183	-179
O&M cost [2]	58	71	87
Fuel cost savings [3]	348	164	47
Net savings [3]-[1]-[2]	*200*	*276*	*139*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	43	-88	-87
O&M cost [2]	58	71	87
Fuel cost savings [3]	302	137	33
Net savings [3]-[1]-[2]	*201*	*154*	*33*

<u>TLC20 – 2030 (LEVD_25)</u>

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	419	-114	-107
O&M cost [2]	-62	-87	-4
Fuel cost savings [3]	1,159	608	297
Net savings [3]-[1]-[2]	*802*	*810*	*407*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	328	-89	-84
O&M cost [2]	-26	-36	-2
Fuel cost savings [3]	1,025	710	515
Net savings [3]-[1]-[2]	*723*	*836*	*600*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	158	-43	-40
O&M cost [2]	-26	-36	-2
Fuel cost savings [3]	841	583	429
Net savings [3]-[1]-[2]	*708*	*662*	*471*

<u>TLC25 – 2025 (LEVD_25)</u>

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	229	-153	-157
O&M cost [2]	1	185	205
Fuel cost savings [3]	514	169	23
Net savings [3]-[1]-[2]	*149*	*138*	*-25*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	179	-120	-123
O&M cost [2]	58	79	87
Fuel cost savings [3]	482	282	195
Net savings [3]-[1]-[2]	*245*	*323*	*230*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	86	-58	-59
O&M cost [2]	58	79	87
Fuel cost savings [3]	416	232	156
Net savings [3]-[1]-[2]	*272*	*212*	*128*

<u>TLC25 – 2030 (LEVD_25)</u>

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	682	22	3
O&M cost [2]	-60	-95	-14
Fuel cost savings [3]	1,521	966	673
Net savings [3]-[1]-[2]	*899*	*1,039*	*684*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	533	17	2
O&M cost [2]	-26	-40	-6
Fuel cost savings [3]	1,325	1,009	826
Net savings [3]-[1]-[2]	*817*	*1,032*	*830*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	257	8	1
O&M cost [2]	-26	-40	-6
Fuel cost savings [3]	1,084	825	681
Net savings [3]-[1]-[2]	*853*	*858*	*686*

<u>TLC30 – 2025 (LEVD_25)</u>

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	380	-64	-71
O&M cost [2]	1	205	210
Fuel cost savings [3]	661	305	209
Net savings [3]-[1]-[2]	*152*	*163*	*70*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	297	-50	-56
O&M cost [2]	54	86	88
Fuel cost savings [3]	614	407	351
Net savings [3]-[1]-[2]	*263*	*371*	*319*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	143	-24	-27
O&M cost [2]	54	86	88
Fuel cost savings [3]	527	334	286
Net savings [3]-[1]-[2]	*329*	*272*	*225*

TLC30 – 2030 (LEVD_25)

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,020	203	147
O&M cost [2]	-96	-106	-25
Fuel cost savings [3]	1,802	1,326	1,049
Net savings [3]-[1]-[2]	*878*	*1,229*	*927*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	799	159	115
O&M cost [2]	-40	-44	-11
Fuel cost savings [3]	1,576	1,309	1,137
Net savings [3]-[1]-[2]	*818*	*1,194*	*1,033*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	385	77	55
O&M cost [2]	-40	-44	-11
Fuel cost savings [3]	1,292	1,069	934
Net savings [3]-[1]-[2]	*947*	*1,037*	*890*

TLC40 – 2025 (LEVD_25)

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	747	160	85
O&M cost [2]	1	129	173
Fuel cost savings [3]	922	748	570
Net savings [3]-[1]-[2]	*78*	*460*	*312*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	585	125	66
O&M cost [2]	40	54	73
Fuel cost savings [3]	866	773	670
Net savings [3]-[1]-[2]	*241*	*595*	*531*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	282	60	32
O&M cost [2]	40	54	73
Fuel cost savings [3]	742	645	551
Net savings [3]-[1]-[2]	*420*	*531*	*446*

TLC40 – 2030 (LEVD_25)

LEVD_25	***Net savings from a societal perspective (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,812	768	649
O&M cost [2]	-157	-172	-144
Fuel cost savings [3]	2,220	2,026	1,896
Net savings [3]-[1]-[2]	*565*	*1,430*	*1,391*

LEVD_25	***TCO-first user (5 years) (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,419	601	507
O&M cost [2]	-66	-72	-60
Fuel cost savings [3]	1,992	1,896	1,825
Net savings [3]-[1]-[2]	*639*	*1,367*	*1,378*

LEVD_25	***TCO-second user (years 6-10) (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	684	290	245
O&M cost [2]	-66	-72	-60
Fuel cost savings [3]	1,640	1,548	1,488
Net savings [3]-[1]-[2]	*1,022*	*1,331*	*1,303*

TLC20 – 2025 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	115	-230	-231
O&M cost [2]	1	178	255
Fuel cost savings [3]	354	-50	-334
Net savings [3]-[1]-[2]	*100*	*3*	*-358*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	90	-180	-181
O&M cost [2]	58	74	107
Fuel cost savings [3]	348	103	-70
Net savings [3]-[1]-[2]	*200*	*209*	*5*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	43	-87	-87
O&M cost [2]	58	74	107
Fuel cost savings [3]	302	94	-54
Net savings [3]-[1]-[2]	*201*	*107*	*-73*

<u>TLC20 – 2030 (LEVD_50)</u>

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	419	-117	-120
O&M cost [2]	-62	-66	40
Fuel cost savings [3]	1,159	463	115
Net savings [3]-[1]-[2]	*802*	*645*	*195*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	328	-92	-94
O&M cost [2]	-26	-27	17
Fuel cost savings [3]	1,025	622	410
Net savings [3]-[1]-[2]	*723*	*741*	*487*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	158	-44	-45
O&M cost [2]	-26	-27	17
Fuel cost savings [3]	841	518	348
Net savings [3]-[1]-[2]	*708*	*589*	*377*

<u>TLC25 – 2025 (LEVD_50)</u>

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	229	-150	-168
O&M cost [2]	1	183	239
Fuel cost savings [3]	514	128	-156
Net savings [3]-[1]-[2]	*149*	*96*	*-227*

LEVD_50	*TCO-first user (5 years) (EUR/car)*		
TLC25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	179	-118	-131
O&M cost [2]	58	78	102
Fuel cost savings [3]	482	252	80
Net savings [3]-[1]-[2]	*245*	*292*	*110*

LEVD_50	*TCO-second user (years 6-10) (EUR/car)*		
TLC25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	86	-57	-63
O&M cost [2]	58	78	102
Fuel cost savings [3]	416	218	70
Net savings [3]-[1]-[2]	*272*	*197*	*32*

TLC25 – 2030 (LEVD_50)

LEVD_50	*Net savings from a societal perspective (EUR/car)*		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	682	5	-26
O&M cost [2]	-60	-87	15
Fuel cost savings [3]	1,521	832	484
Net savings [3]-[1]-[2]	*899*	*914*	*494*

LEVD_50	*TCO-first user (5 years) (EUR/car)*		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	533	4	-20
O&M cost [2]	-26	-37	6
Fuel cost savings [3]	1,325	927	715
Net savings [3]-[1]-[2]	*817*	*959*	*728*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	257	2	-10
O&M cost [2]	-26	-37	6
Fuel cost savings [3]	1,084	765	596
Net savings [3]-[1]-[2]	*853*	*800*	*600*

TLC30 – 2025 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	380	-62	-91
O&M cost [2]	1	186	243
Fuel cost savings [3]	661	290	27
Net savings [3]-[1]-[2]	*152*	*165*	*-125*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC30 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	297	-49	-71
O&M cost [2]	54	78	102
Fuel cost savings [3]	614	392	234
Net savings [3]-[1]-[2]	*263*	*363*	*204*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	143	-24	-34
O&M cost [2]	54	78	102
Fuel cost savings [3]	527	333	199
Net savings [3]-[1]-[2]	*329*	*278*	*132*

TLC30 – 2030 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,020	171	106
O&M cost [2]	-96	-88	16
Fuel cost savings [3]	1,802	1,197	863
Net savings [3]-[1]-[2]	*878*	*1,115*	*741*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	799	133	83
O&M cost [2]	-40	-37	6
Fuel cost savings [3]	1,576	1,228	1,029
Net savings [3]-[1]-[2]	*818*	*1,132*	*939*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC30 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	385	64	40
O&M cost [2]	-40	-37	6
Fuel cost savings [3]	1,292	1,011	853
Net savings [3]-[1]-[2]	*947*	*984*	*806*

TLC40 – 2025 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	747	157	73
O&M cost [2]	1	133	161
Fuel cost savings [3]	922	728	513
Net savings [3]-[1]-[2]	*78*	*438*	*279*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	585	122	57
O&M cost [2]	40	56	67
Fuel cost savings [3]	866	756	632
Net savings [3]-[1]-[2]	*241*	*578*	*507*

LEVD_50	***TCO-second user (years 6-10) (EUR/car)***		
TLC40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	282	59	27
O&M cost [2]	40	56	67
Fuel cost savings [3]	742	636	529
Net savings [3]-[1]-[2]	*420*	*522*	*434*

TLC40 – 2030 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,812	785	547
O&M cost [2]	-157	-176	-117
Fuel cost savings [3]	2,220	2,040	1,748
Net savings [3]-[1]-[2]	*565*	*1,432*	*1,318*

LEVD_50	***TCO-first user (5 years) (EUR/car)***		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,419	614	428
O&M cost [2]	-66	-74	-49
Fuel cost savings [3]	1,992	1,904	1,739
Net savings [3]-[1]-[2]	*639*	*1,363*	*1,360*

LEVD_50	*TCO-second user (years 6-10) (EUR/car)*		
TLC40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	684	296	206
O&M cost [2]	-66	-74	-49
Fuel cost savings [3]	1,640	1,555	1,420
Net savings [3]-[1]-[2]	*1,022*	*1,333*	*1,263*

Sensitivity – economic impacts under varying cost assumptions for the battery

As explained in Section 6.5.1 of the impact assessment report, to assess the impacts of the options setting a LEV mandate/benchmark, the following technology costs were used: battery pack costs of around 100 EUR/kWh in 2025 and 65 EUR/kWh in 2030.

For the purpose of analysing the sensitivity of the battery cost assumptions, a different evolution is considered, corresponding to battery pack costs of around 130 EUR/kWh in 2025 and 100 EUR/kWh in 2030, in line with the "Low" costs in Section 8.2.1.1.4 of the impact assessment report.

Table 31 documents how the net savings vary with the differing battery cost assumptions for the option LEV%_A.

Results are presented for the savings over a vehicle lifetime (TCO-15-years) from an end-user perspective.

Table 31: Detailed overview of the net savings (TCO-15 years) in EUR/car under different options for the EU-wide fleet CO_2 target (TLC) combined with a LEV incentive (LEV mandate/benchmark as in option LEV%_A and different LEV definitions LEVD) for 2025 and 2030 passenger cars with varying battery costs ("Low" and "Very Low")

LEVD_ZEV	***TCO-15 years (EUR/car)***		
2025	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	383	583	703
Battery cost "Very Low"	620	820	1,055

LEVD_ZEV	***TCO-15 years (EUR/car)***		
2030	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	1,349	1,760	1,670
Battery cost "Very Low"	1,623	2,155	2,303

LEVD_25	***TCO-15 years (EUR/car)***		
2025	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	279	382	646
Battery cost "Very Low"	462	608	1,002

LEVD_25	***TCO-15 years (EUR/car)***		
2030	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	866	1,478	1,685
Battery cost "Very Low"	1,449	2,048	2,325

LEVD_50	***TCO-15 years (EUR/car)***		
2025	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	-4	283	493
Battery cost "Very Low"	352	607	978

LEVD_50	***TCO-15 years (EUR/car)***		
2030	***TLC20***	***TLC30***	***TLC40***
Battery cost "Low"	597	1,297	1,707
Battery cost "Very Low"	1,289	1,947	2,317

Net savings are lower when battery costs are at the "Low" levels. However the impacts under different battery cost assumptions remain generally positive, with higher capital costs with respect to the baseline compensated by higher fuel savings.

8.4.2 Vans: assessment of options with additional incentives for low-emission vehicles: economic and social impacts

Table 32 provides a detailed overview of the net savings achieved under the different LEV incentives options using the different indicators used in the economic and social analysis.

Table 32: Detailed overview of the net savings in EUR/van under different LEV incentive options (LEV definitions, CO_2 targets and LEV mandate/benchmark levels) for 2025 and 2030 vans using several economic (societal perspective, TCO-first user) and social (TCO-second user) impact indicators

TLV20 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	232	39	173
O&M cost [2]	1	-134	-237
Fuel cost savings [3]	1,002	253	-340
Net savings [3]-[1]-[2]	*810*	*349*	*-276*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	144	24	107
O&M cost [2]	-17	-58	-102
Fuel cost savings [3]	1,016	603	264
Net savings [3]-[1]-[2]	*889*	*637*	*259*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	69	12	52
O&M cost [2]	-17	-58	-102
Fuel cost savings [3]	707	436	212
Net savings [3]-[1]-[2]	*655*	*482*	*262*

TLV20 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	426	90	140
O&M cost [2]	-51	-236	-317
Fuel cost savings [3]	2,063	905	505
Net savings [3]-[1]-[2]	*1,688*	*1,051*	*682*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	265	56	87
O&M cost [2]	-22	-101	-136
Fuel cost savings [3]	2,026	1,301	1,062
Net savings [3]-[1]-[2]	*1,783*	*1,346*	*1,111*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	128	27	42
O&M cost [2]	-22	-101	-136
Fuel cost savings [3]	1,388	909	752
Net savings [3]-[1]-[2]	*1,282*	*983*	*846*

TLV25 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	355	115	226
O&M cost [2]	1	-136	-225
Fuel cost savings [3]	1,265	557	36
Net savings [3]-[1]-[2]	*962*	*577*	*35*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	221	71	141
O&M cost [2]	-23	-58	-96
Fuel cost savings [3]	1,281	893	600
Net savings [3]-[1]-[2]	*1,083*	*880*	*556*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	106	34	68
O&M cost [2]	-23	-58	-96
Fuel cost savings [3]	893	637	444
Net savings [3]-[1]-[2]	*809*	*661*	*473*

TLV25 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	620	210	266
O&M cost [2]	-56	-239	-319
Fuel cost savings [3]	2,600	1,473	1,051
Net savings [3]-[1]-[2]	*2,037*	*1,502*	*1,105*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	386	130	165
O&M cost [2]	-24	-102	-137
Fuel cost savings [3]	2,546	1,841	1,595
Net savings [3]-[1]-[2]	*2,184*	*1,813*	*1,567*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	186	63	80
O&M cost [2]	-24	-102	-137
Fuel cost savings [3]	1,743	1,278	1,117
Net savings [3]-[1]-[2]	*1,582*	*1,317*	*1,174*

TLV40 – 2025 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	877	406	459
O&M cost [2]	1	-154	-249
Fuel cost savings [3]	2,061	1,564	1,050
Net savings [3]-[1]-[2]	*1,291*	*1,312*	*840*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	545	252	285
O&M cost [2]	-46	-66	-107
Fuel cost savings [3]	2,115	1,851	1,570
Net savings [3]-[1]-[2]	*1,616*	*1,665*	*1,392*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	263	122	138
O&M cost [2]	-46	-66	-107
Fuel cost savings [3]	1,475	1,302	1,117
Net savings [3]-[1]-[2]	*1,258*	*1,246*	*1,086*

TLV40 – 2030 (LEVD_ZEV)

LEVD_ZEV	***Net savings from a societal perspective (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,582	696	718
O&M cost [2]	-145	-278	-362
Fuel cost savings [3]	3,827	3,122	2,721
Net savings [3]-[1]-[2]	*2,389*	*2,704*	*2,365*

LEVD_ZEV	***TCO-first user (5 years) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	984	433	446
O&M cost [2]	-62	-119	-155
Fuel cost savings [3]	3,833	3,389	3,162
Net savings [3]-[1]-[2]	*2,912*	*3,076*	*2,871*

LEVD_ZEV	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	474	209	215
O&M cost [2]	-62	-119	-155
Fuel cost savings [3]	2,629	2,334	2,186
Net savings [3]-[1]-[2]	*2,217*	*2,245*	*2,126*

TLV20 – 2025 (LEVD_40)

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	232	47	203
O&M cost [2]	1	-124	-221
Fuel cost savings [3]	1,002	498	27
Net savings [3]-[1]-[2]	*810*	*575*	*45*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	144	29	126
O&M cost [2]	-17	-53	-95
Fuel cost savings [3]	1,016	715	435
Net savings [3]-[1]-[2]	*889*	*739*	*404*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	69	14	61
O&M cost [2]	-17	-53	-95
Fuel cost savings [3]	707	508	322
Net savings [3]-[1]-[2]	*655*	*547*	*356*

<u>TLV20 – 2030 (LEVD_40)</u>

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	426	57	209
O&M cost [2]	-51	-186	-327
Fuel cost savings [3]	2,063	1,266	666
Net savings [3]-[1]-[2]	*1,688*	*1,395*	*784*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	265	35	130
O&M cost [2]	-22	-80	-140
Fuel cost savings [3]	2,026	1,492	1,119
Net savings [3]-[1]-[2]	*1,783*	*1,537*	*1,129*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	128	17	63
O&M cost [2]	-22	-80	-140
Fuel cost savings [3]	1,388	1,032	784
Net savings [3]-[1]-[2]	*1,282*	*1,094*	*861*

<u>TLV25 – 2025 (LEVD_40)</u>

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	355	145	232
O&M cost [2]	1	-142	-206
Fuel cost savings [3]	1,265	729	420
Net savings [3]-[1]-[2]	*962*	*726*	*394*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	221	90	144
O&M cost [2]	-23	-61	-88
Fuel cost savings [3]	1,281	961	778
Net savings [3]-[1]-[2]	*1,083*	*931*	*722*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	106	44	70
O&M cost [2]	-23	-61	-88
Fuel cost savings [3]	893	679	558
Net savings [3]-[1]-[2]	*809*	*696*	*577*

<u>TLV25 – 2030 (LEVD_40)</u>

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	620	170	270
O&M cost [2]	-56	-176	-306
Fuel cost savings [3]	2,600	1,875	1,354
Net savings [3]-[1]-[2]	*2,037*	*1,881*	*1,390*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	386	105	168
O&M cost [2]	-24	-75	-131
Fuel cost savings [3]	2,546	2,060	1,733
Net savings [3]-[1]-[2]	*2,184*	*2,030*	*1,696*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	186	51	81
O&M cost [2]	-24	-75	-131
Fuel cost savings [3]	1,743	1,420	1,202
Net savings [3]-[1]-[2]	*1,582*	*1,445*	*1,253*

<u>TLV40 – 2025 (LEVD_40)</u>

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	877	484	586
O&M cost [2]	1	-265	-347
Fuel cost savings [3]	2,061	1,135	725
Net savings [3]-[1]-[2]	*1,291*	*916*	*485*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	545	301	364
O&M cost [2]	-46	-114	-149
Fuel cost savings [3]	2,115	1,589	1,343
Net savings [3]-[1]-[2]	*1,616*	*1,401*	*1,127*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	263	145	176
O&M cost [2]	-46	-114	-149
Fuel cost savings [3]	1,475	1,126	963
Net savings [3]-[1]-[2]	*1,258*	*1,095*	*936*

TLV40 – 2030 (LEVD_40)

LEVD_40	***Net savings from a societal perspective (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,582	717	778
O&M cost [2]	-145	-359	-508
Fuel cost savings [3]	3,827	2,801	2,179
Net savings [3]-[1]-[2]	*2,389*	*2,444*	*1,909*

LEVD_40	***TCO-first user (5 years) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	984	446	483
O&M cost [2]	-62	-154	-218
Fuel cost savings [3]	3,833	3,176	2,781
Net savings [3]-[1]-[2]	*2,912*	*2,884*	*2,516*

LEVD_40	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	474	215	233
O&M cost [2]	-62	-154	-218
Fuel cost savings [3]	2,629	2,192	1,930
Net savings [3]-[1]-[2]	*2,217*	*2,131*	*1,914*

<u>TLV20 – 2025 (LEVD_50)</u>

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	232	188	349
O&M cost [2]	1	-242	-333
Fuel cost savings [3]	1,002	-360	-931
Net savings [3]-[1]-[2]	*810*	*-306*	*-947*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV20 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	144	117	217
O&M cost [2]	-17	-104	-143
Fuel cost savings [3]	1,016	253	-78
Net savings [3]-[1]-[2]	*889*	*240*	*-153*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	69	56	105
O&M cost [2]	-17	-104	-143
Fuel cost savings [3]	707	204	-14
Net savings [3]-[1]-[2]	*655*	*252*	*24*

<u>TLV20 – 2030 (LEVD_50)</u>

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	426	239	362
O&M cost [2]	-51	-394	-497
Fuel cost savings [3]	2,063	95	-371
Net savings [3]-[1]-[2]	*1,688*	*249*	*-236*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	265	149	225
O&M cost [2]	-22	-169	-213
Fuel cost savings [3]	2,026	811	542
Net savings [3]-[1]-[2]	*1,783*	*831*	*530*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV20 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	128	72	109
O&M cost [2]	-22	-169	-213
Fuel cost savings [3]	1,388	587	410
Net savings [3]-[1]-[2]	*1,282*	*684*	*515*

<u>TLV25 – 2025 (LEVD_50)</u>

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	355	251	411
O&M cost [2]	1	-241	-330
Fuel cost savings [3]	1,265	-43	-641
Net savings [3]-[1]-[2]	*962*	*-53*	*-721*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV25 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	221	156	255
O&M cost [2]	-23	-103	-142
Fuel cost savings [3]	1,281	553	203
Net savings [3]-[1]-[2]	*1,083*	*500*	*89*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	106	75	123
O&M cost [2]	-23	-103	-142
Fuel cost savings [3]	893	412	181
Net savings [3]-[1]-[2]	*809*	*441*	*199*

TLV25 – 2030 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	620	332	454
O&M cost [2]	-56	-391	-500
Fuel cost savings [3]	2,600	693	102
Net savings [3]-[1]-[2]	*2,037*	*752*	*148*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	386	206	282
O&M cost [2]	-24	-168	-214
Fuel cost savings [3]	2,546	1,371	1,007
Net savings [3]-[1]-[2]	*2,184*	*1,332*	*939*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV25 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	186	99	136
O&M cost [2]	-24	-168	-214
Fuel cost savings [3]	1,743	969	729
Net savings [3]-[1]-[2]	*1,582*	*1,037*	*807*

TLV40 – 2025 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	877	464	555
O&M cost [2]	1	-238	-348
Fuel cost savings [3]	2,061	1,085	475
Net savings [3]-[1]-[2]	*1,291*	*859*	*268*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV40 – 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	545	288	345
O&M cost [2]	-46	-102	-152
Fuel cost savings [3]	2,115	1,587	1,241
Net savings [3]-[1]-[2]	*1,616*	*1,400*	*1,047*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2025	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	263	139	166
O&M cost [2]	-46	-102	-152
Fuel cost savings [3]	1,475	1,127	898
Net savings [3]-[1]-[2]	*1,258*	*1,090*	*884*

TLV40 – 2030 (LEVD_50)

LEVD_50	***Net savings from a societal perspective (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	1,582	733	764
O&M cost [2]	-145	-394	-491
Fuel cost savings [3]	3,827	2,541	2,024
Net savings [3]-[1]-[2]	*2,389*	*2,203*	*1,751*

LEVD_50	***TCO-first user (5 years) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	984	455	475
O&M cost [2]	-62	-169	-214
Fuel cost savings [3]	3,833	3,051	2,740
Net savings [3]-[1]-[2]	*2,912*	*2,764*	*2,479*

LEVD_50	***TCO-second user (years 6-10) (EUR/van)***		
TLV40 - 2030	***LEV0***	***LEV%_A***	***LEV%_B***
Capital cost [1]	474	220	229
O&M cost [2]	-62	-169	-214
Fuel cost savings [3]	2,629	2,113	1,908
Net savings [3]-[1]-[2]	*2,217*	*2,062*	*1,894*