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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}

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

1.1 Organisation and timing

The Directorate-General for Climate Action is the lead service for the preparation of the initiative (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	<u>Investment needs / manufacturing costs</u> 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. <u>Benefits</u> 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. <u>Cost / benefits</u> 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	<u>Investment costs / new technologies</u> 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. <u>Benefits</u> 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	<u>Transport costs/prices</u> 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. <u>Benefits</u> 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	<u>Adjustment costs</u> 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. <u>Investment needs</u> 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. <u>Benefits</u> 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.

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[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).

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[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

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[35] Regulation (EU) 2017/352

[36] See Annex 4.6

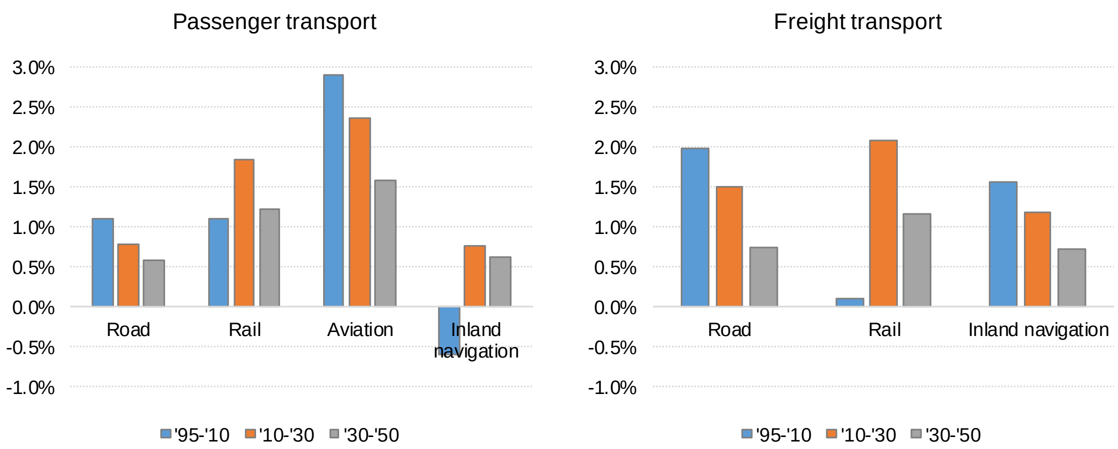
[37] Currently, 15,000 kilometres of federal trunk road and motorways are subject to tolls.

[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.

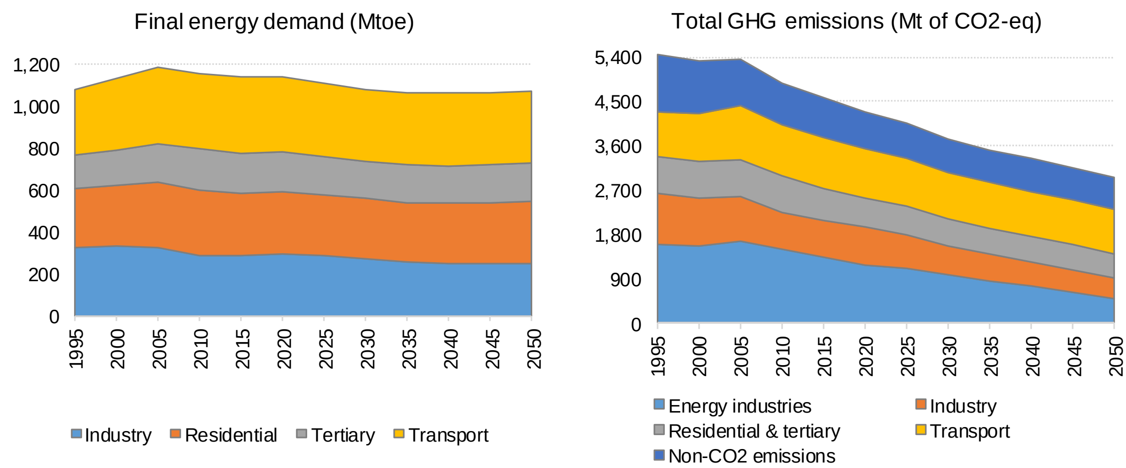
Transport activity of freight inland navigation[40] also benefits from the completion of the TEN-T core and comprehensive network, the promotion of inland waterway transport and the recovery in the economic activity and would grow by 26% by 2030 (1.2% per year) and by 46% during 2010-2050 (0.9% per year).

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.

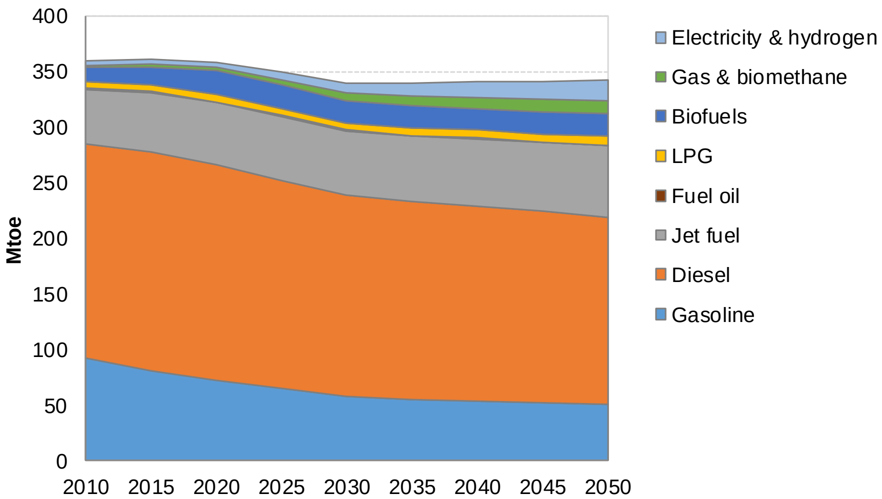
electric vehicles in the total light duty vehicle stock would reach about 6% by 2030 and 15% by 2050 (with the shares of battery electric being 2% in 2030 and 6% in 2050). The uptake of hydrogen would be facilitated by the increased availability of refuelling infrastructure, but its use would remain 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.

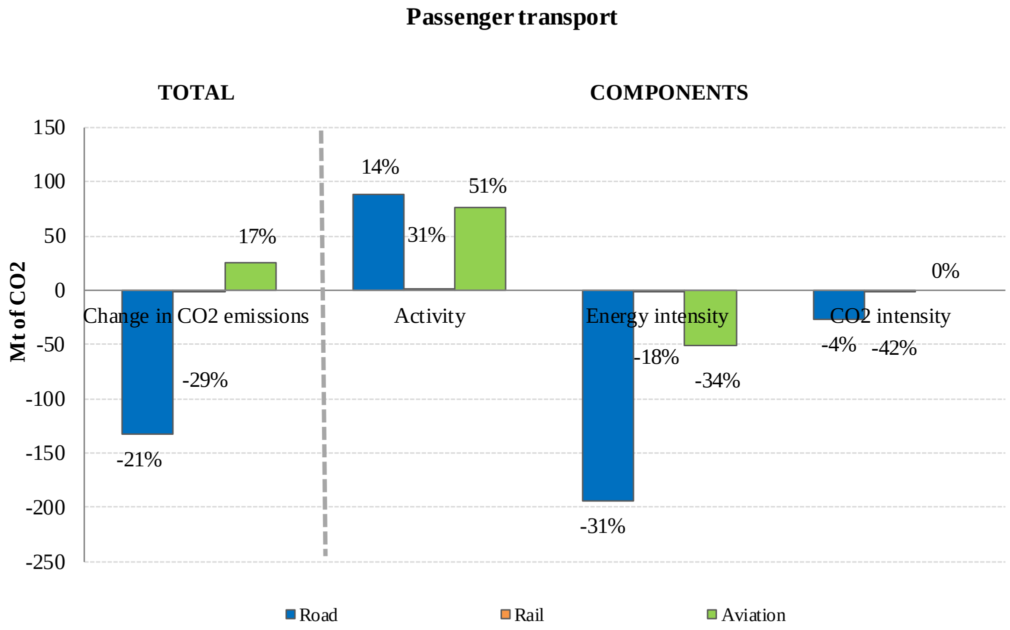
[42] The proposed method is the Montgomery decomposition. For a recent application of the method see: De Boer, P.M.C. (2008) Additive Structural Decomposition Analysis and Index Number Theory: An Empirical Application of the Montgomery Decomposition, Economic Systems Research, 20(1), pp. 97-109.

[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]

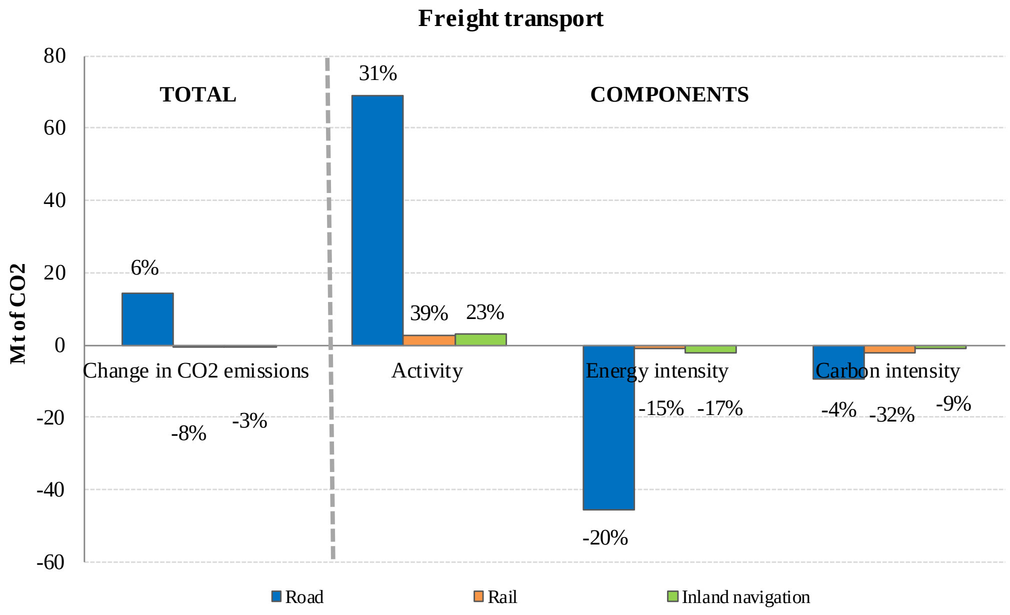
Noise related external costs of transport would continue to increase, by about 17% during 2010-2030 (24% for 2010-2050), driven by the rise in traffic. Thanks to policies in place, external **costs of accidents** are projected to go down by about 46% by 2030 (-42% for 2010-2050) – but still remain high 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).

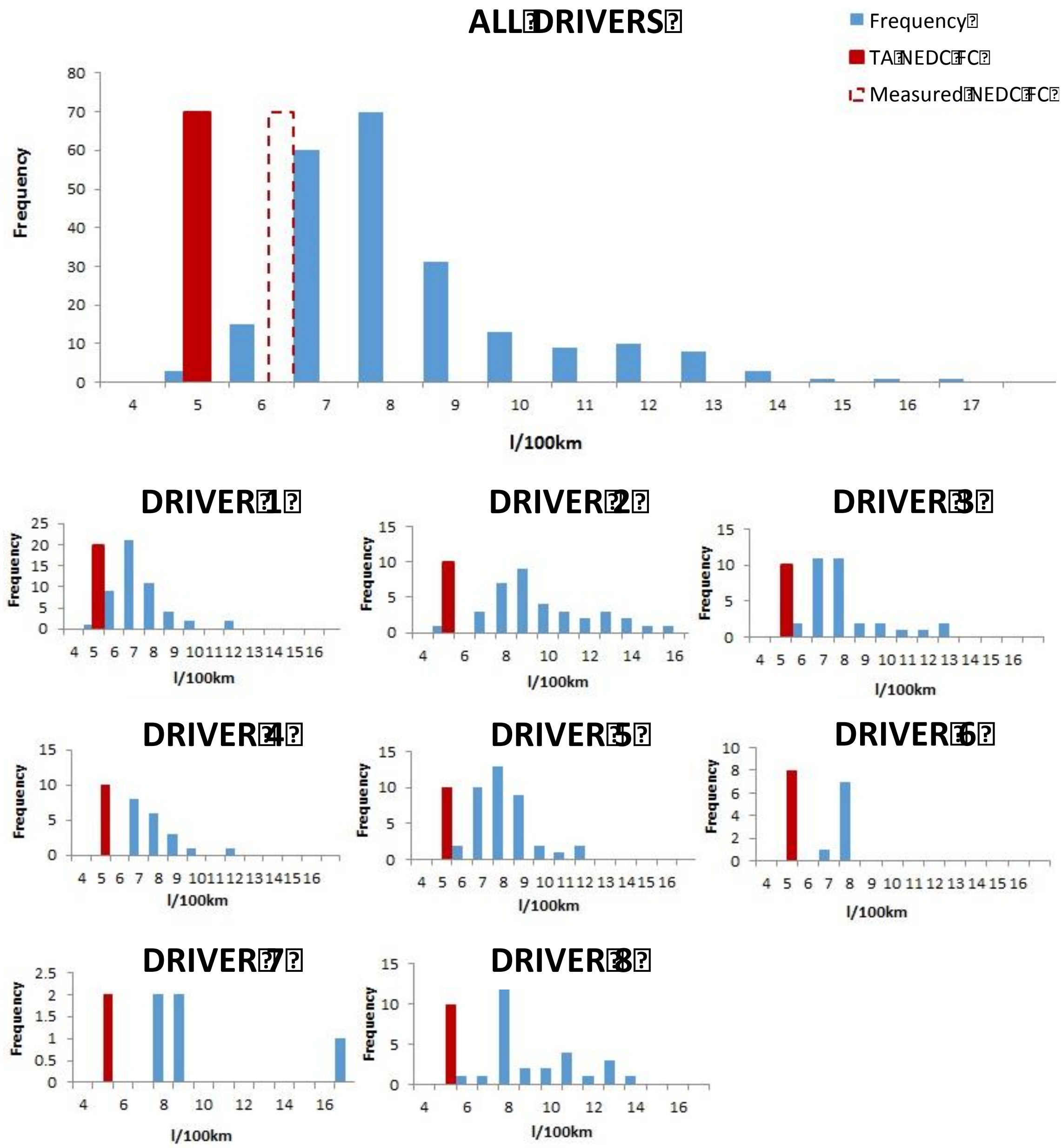
Two types of data sources are used in the analysis, namely (i) data collected during a period of ~6 months from the same vehicle driven by different drivers and in different conditions, and (ii) data collected from different vehicles tested by a few drivers on a limited number of routes. Combining these 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 1^{st} 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

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[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

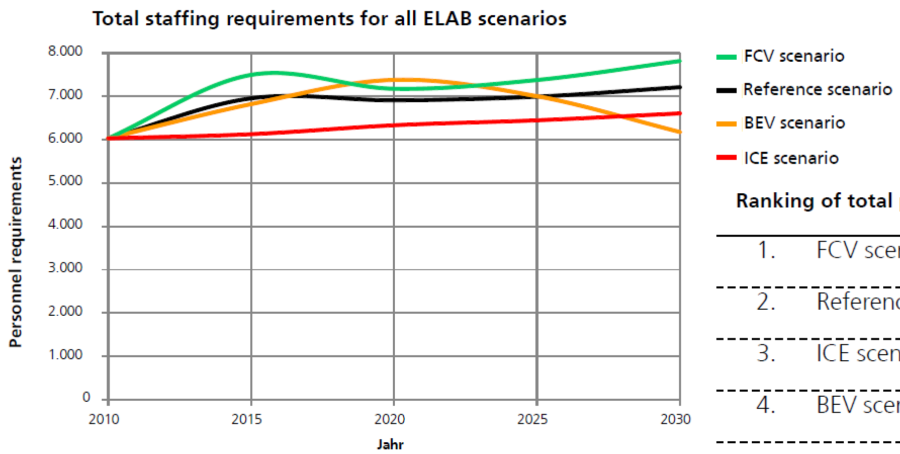
[57] Fraunhofer IAO (2012): Elektromobilität und Beschäftigung – Wirkungen der Elektrifizierung des Antriebsstrangs auf Beschäftigung und Standortumgebung (ELAB), http://www.muse.iao.fraunhofer.de/content/dam/iao/muse/de/documents/AbgeschlosseneProjekte/elab-abschlussbericht.pdf . The study does not 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

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[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

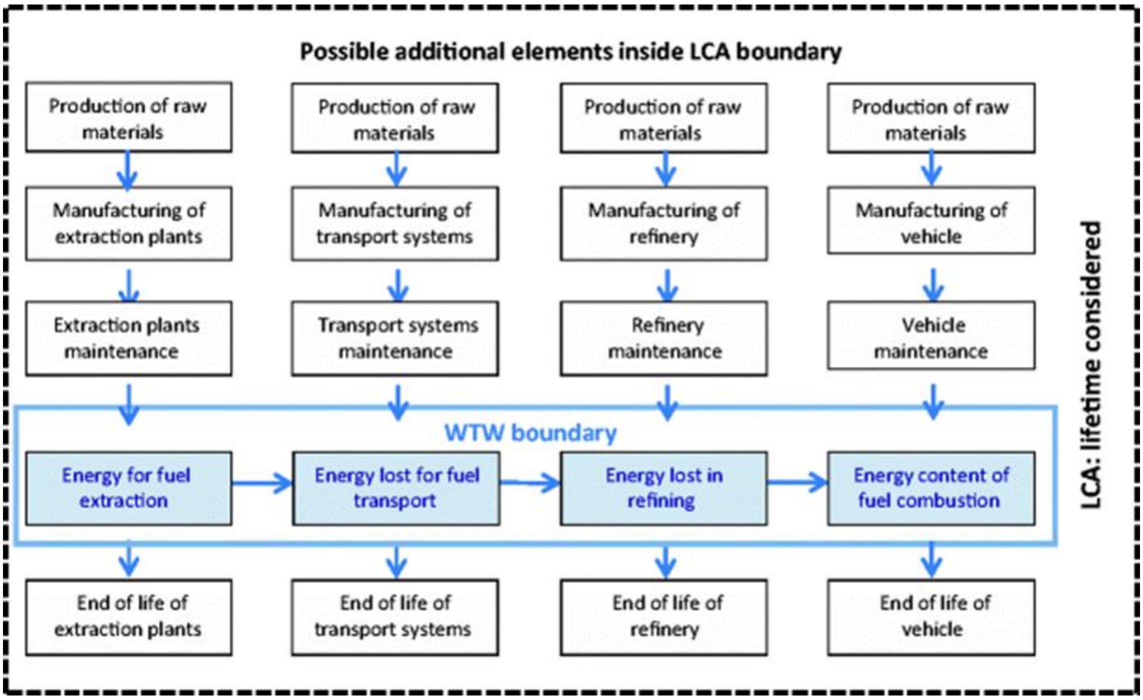
8.1.1 Methodological considerations concerning Well-to-Wheel (WTW) and life-cycle analysis (LCA) approaches

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.

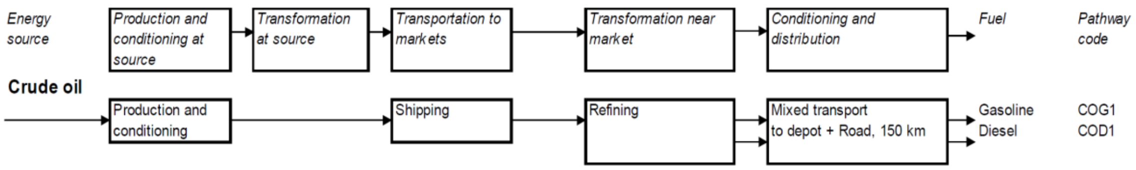
The scope of the well-to-wheel (WTW) analysis considers energy and GHG emissions balances related to the fuel production (Well-to-Tank – WTT) and related to the vehicle use (Tank-to-Wheel – TTW). The WTW emissions are assessed for a wide range of automotive fuels and powertrain options in the EU by the "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**

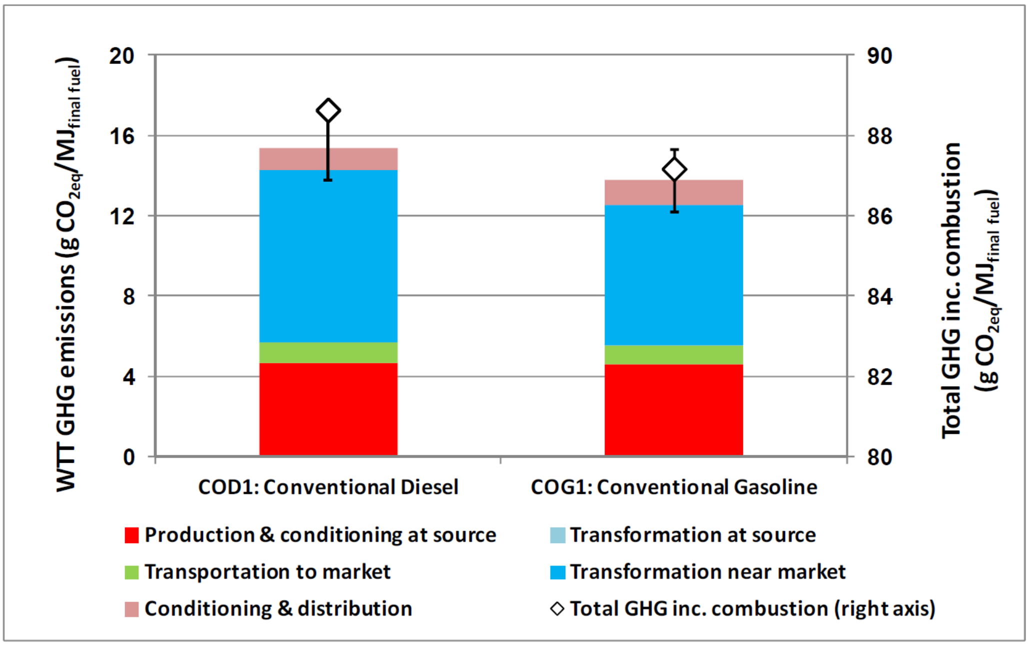
69 JEC - JRC -EUCAR-CONCAWE collaboration (JEC 2014): Tank-to-Wheels **Report - Version 4.a**

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.

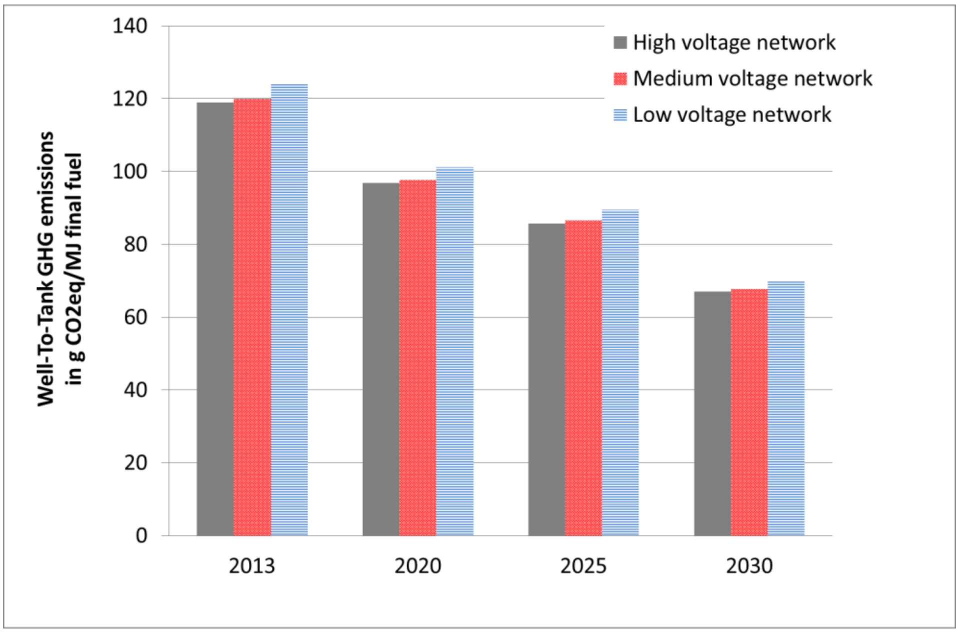
The trajectory of the carbon intensity of the European electricity and steam production over the period 2010-2030, as projected by the PRIMES model in the *EUCO30* scenario[72], was applied on the WTT electricity emissions provided by Moro and Lonza (2017). To this end, in a first step the WTT GHG emission 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

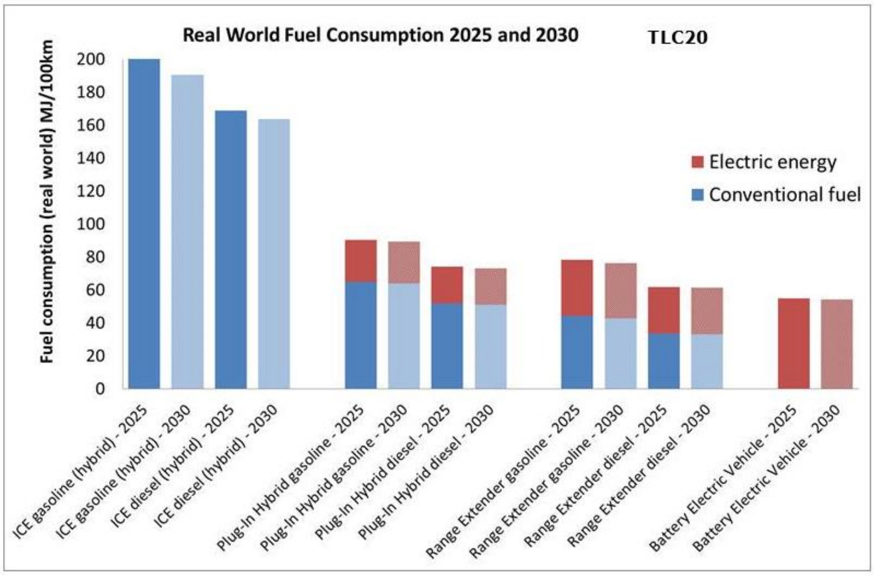
8.1.2.2 Tank-to-wheel analysis

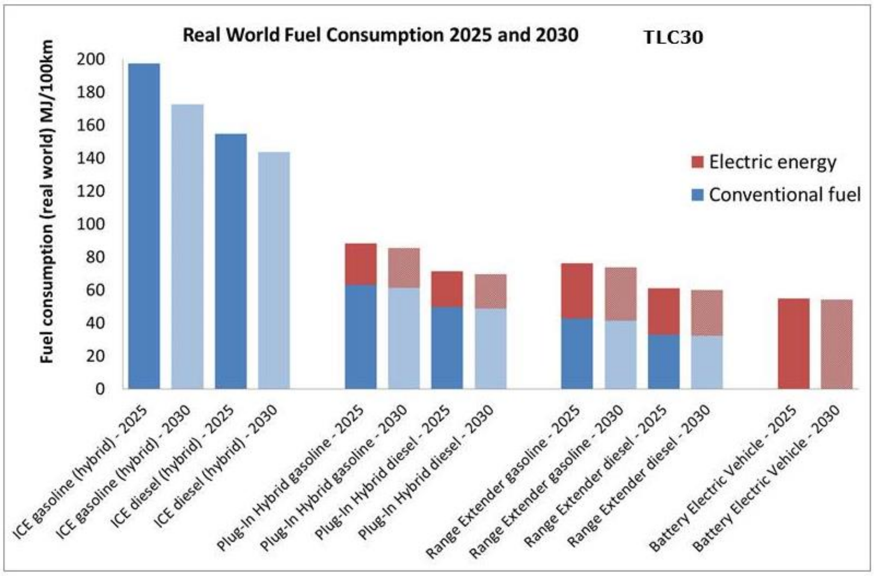
The Tank-to-wheel analysis in this sub-section is based on 'real world' energy consumption figures as used elsewhere in the Impact Assessment. As an illustrative example, the energy consumption of a representative vehicle of the 'lower-medium' category has been considered.

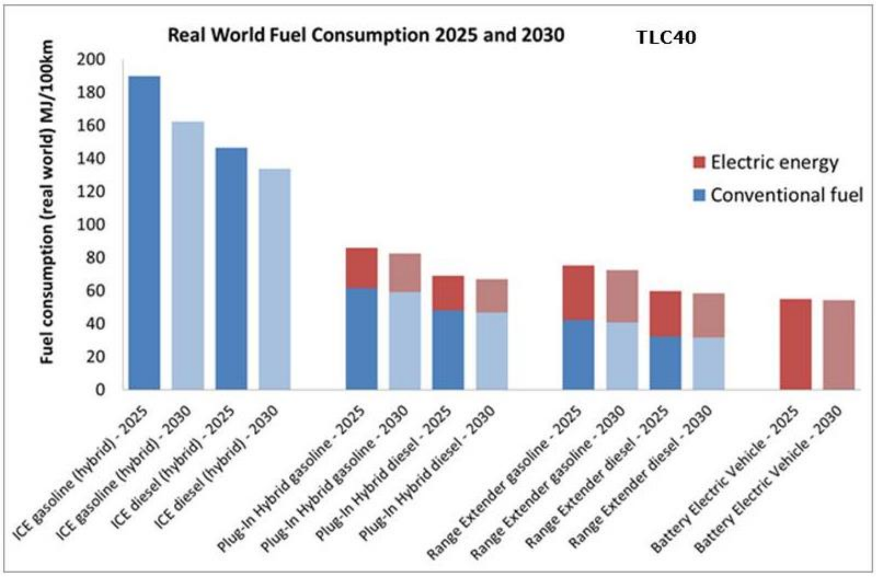
The specific energy consumption of various vehicle types for the years 2025 and 2030 is displayed in Figure 11 for three different policy options regarding the EU-wide fleet CO_2 target level (TLC20, TLC30, TLC40).

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







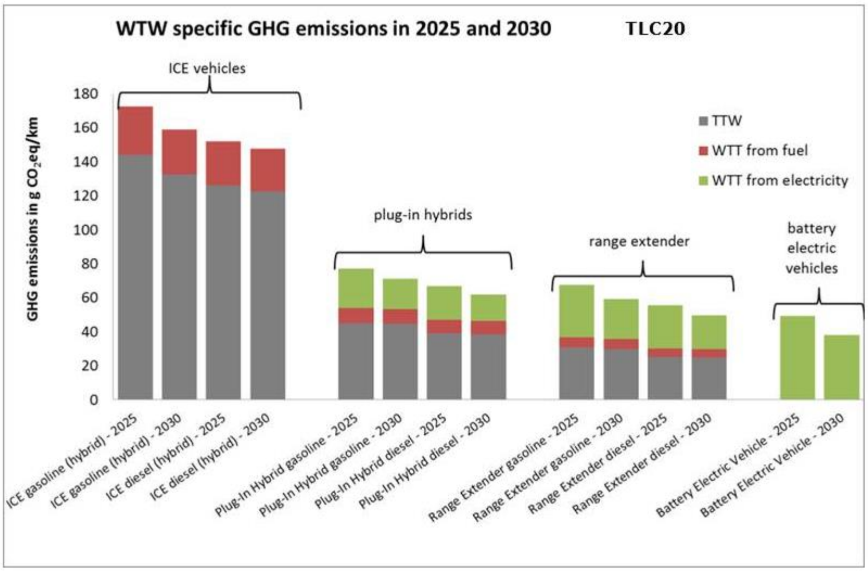
8.1.2.3 Well-to-Wheel analysis

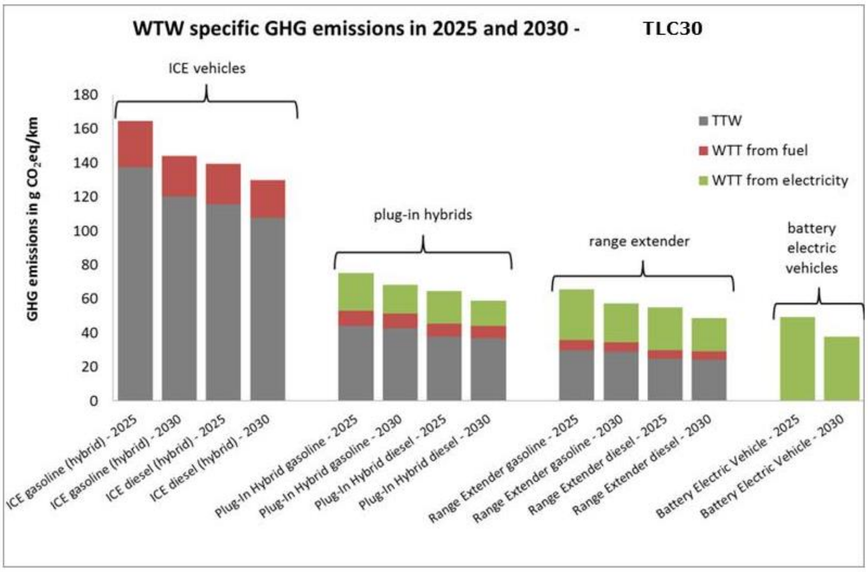
This section brings the information from the previous sections together for a selected number of vehicle types, providing the GHG emission balances that occur from a Well-toWheel (WTW) perspective.

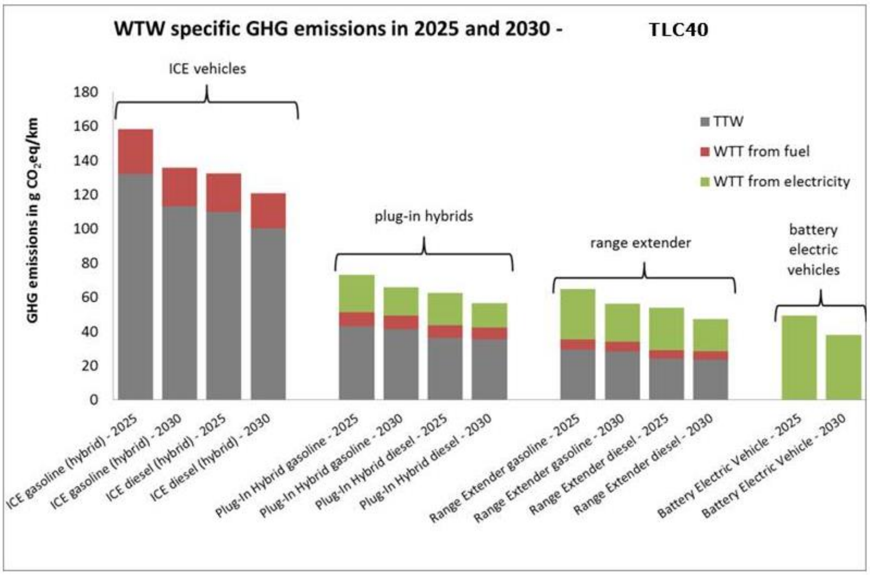
Figure 12 summarises the WTW GHG emissions for 2025 and 2030 passenger car configurations for three CO_2 target level options (TLC20, TLC30 and TLC40). The WTW emissions are disaggregated into those that relate to the use of the vehicle (TTW) and those that stem from the fuel production (WTT), the latter 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.

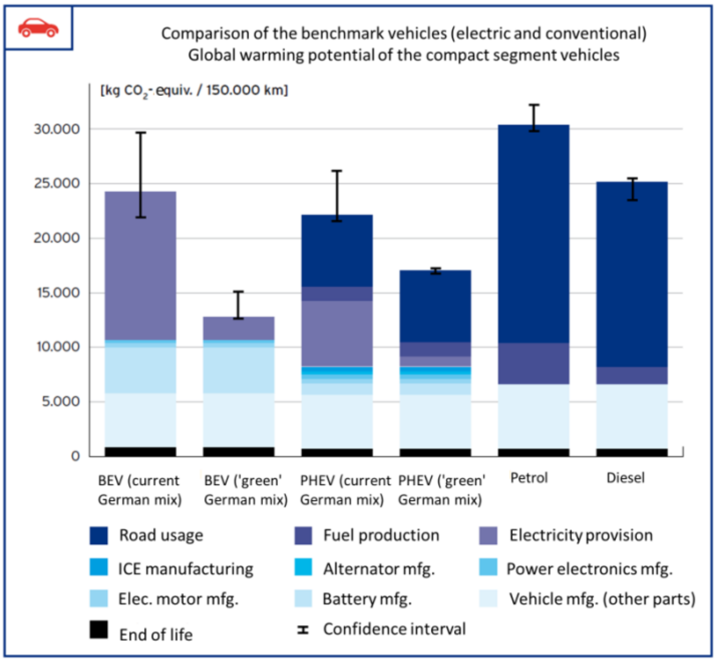
[74] Nordelöf, A., Messagie, M., Tillman, A.-M., Ljunggren Söderman, M., Van Mierlo, J.: Environmental impacts of hybrid, plug-in hybrid, and battery electric vehicles—what can we learn from life cycle assessment? Int J Life Cycle Assess (2014) 19:1866–1890; see also Erratum Int J Life Cycle Assess (2016) 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

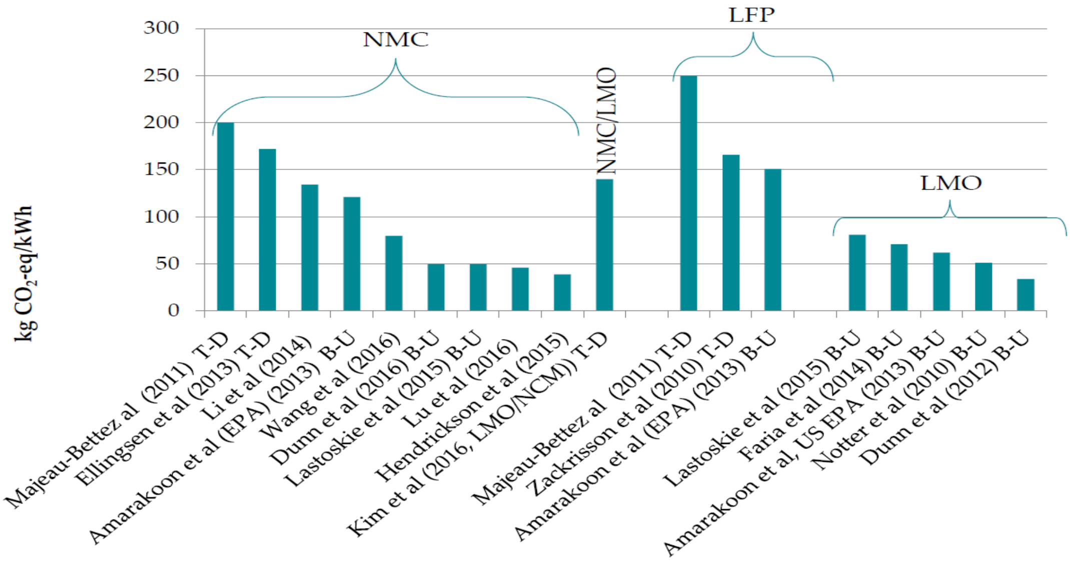
IVL recently performed an extensive literature review concerning the energy consumption and GHG emissions of vehicle battery production[79]. They found that the results among studies differ significantly, as shown in Figure 14.

[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

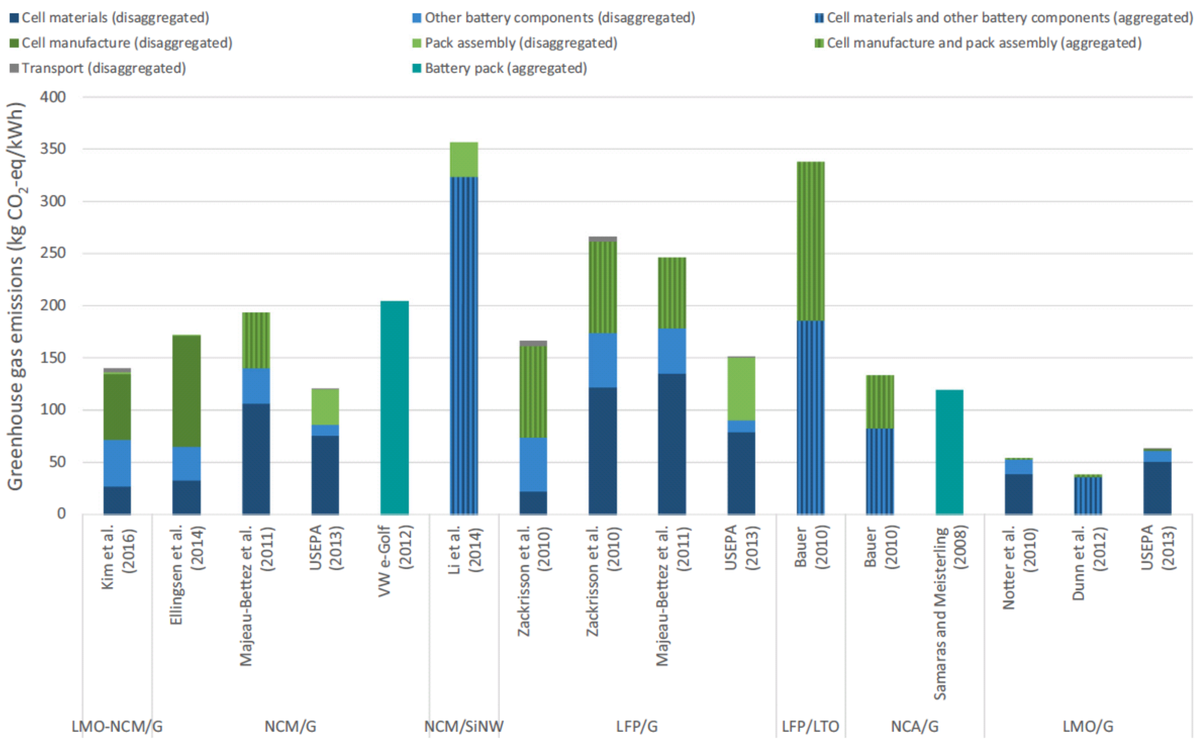


Notes: T-D=Top-down approach for manufacturing and B-U is Bottom-Up approach.

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.

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[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

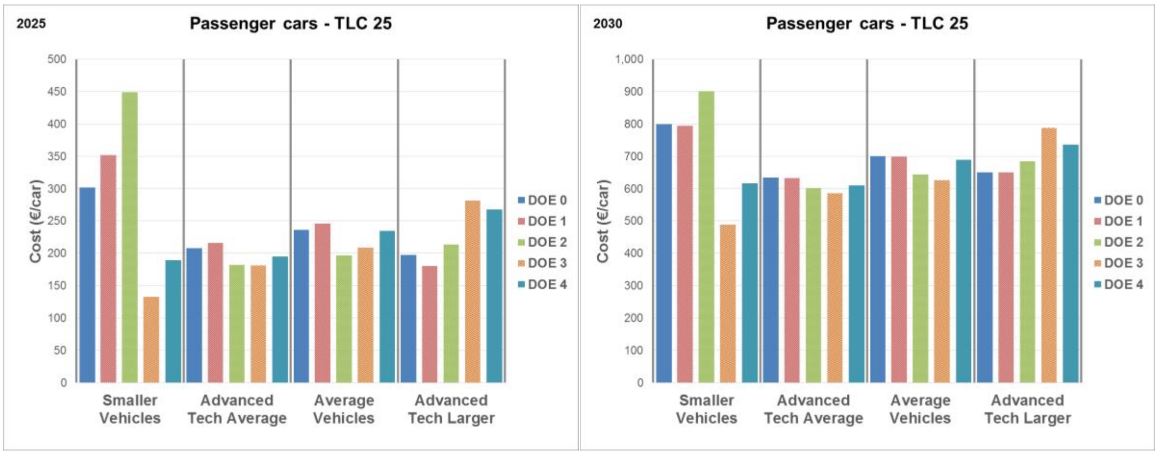
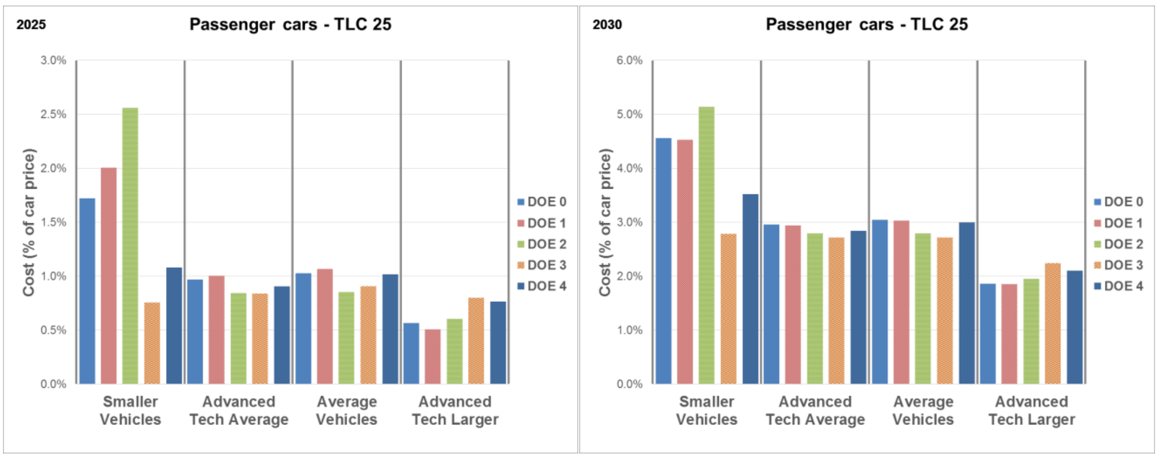


Figure 17: Additional manufacturing costs relative to vehicle price (% of car price) for categories of passenger car manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLC25



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

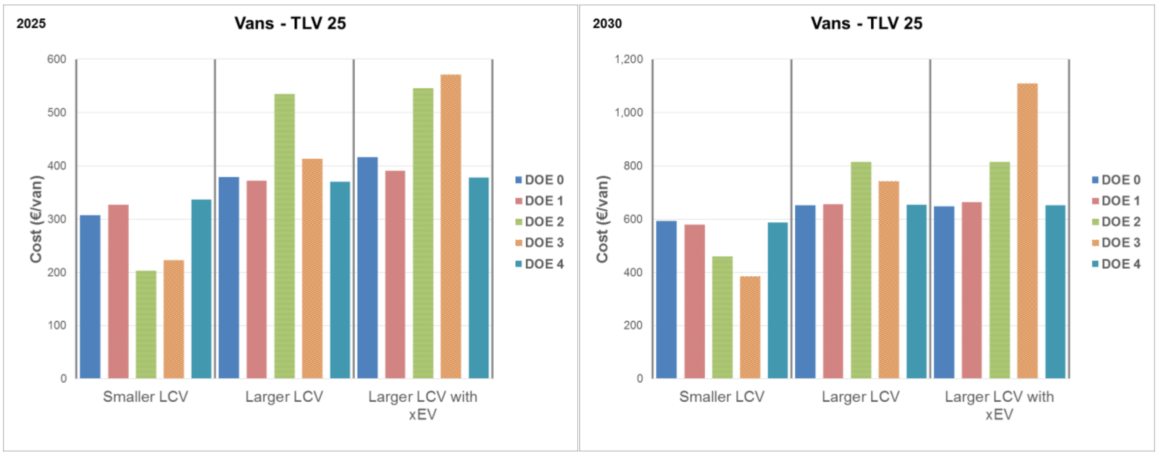
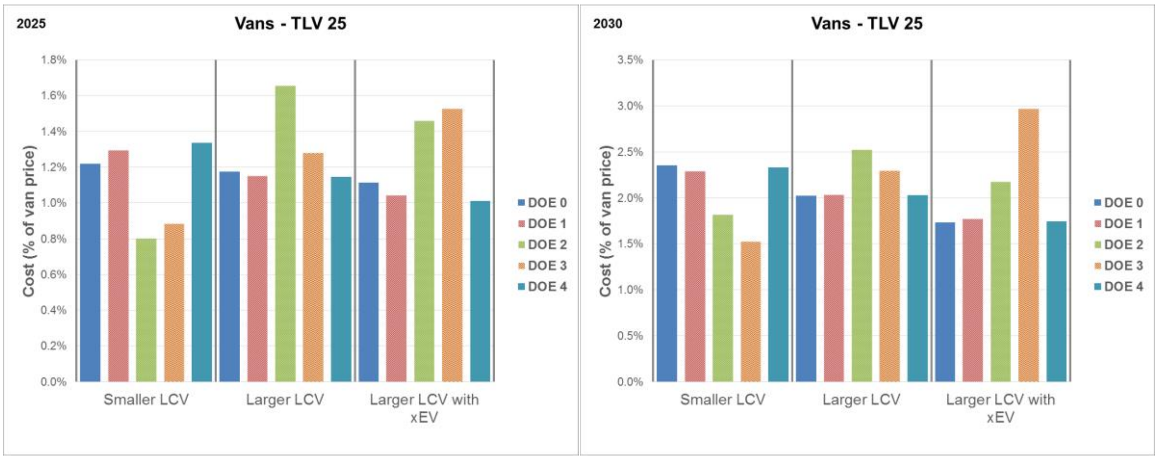


Figure 19: Additional manufacturing costs relative to vehicle price (% of van price) for categories of van manufacturers under different options DOE and with the EU-wide fleet CO_2 target levels as in option TLV25



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

<u>TLC20 – 2025 (LEVD_ZEV)</u>

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*

<u>TLC25 – 2030 (LEVD_ZEV)</u>

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*

TLC20 – 2030 (LEVD_25)

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*

TLC25 – 2025 (LEVD_25)

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*

TLC25 – 2030 (LEVD_25)

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*

TLC30 – 2025 (LEVD_25)

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*

TLC20 – 2030 (LEVD_50)

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*

TLC25 – 2025 (LEVD_50)

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

<u>TLV20 – 2025 (LEVD_ZEV)</u>

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*

<u>TLV20 – 2030 (LEVD_ZEV)</u>

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*

TLV40 – 2025 (LEVD_40)

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*

<u>TLV40 – 2030 (LEVD_40)</u>

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*

TLV25 – 2025 (LEVD_50)

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*