EXECUTIVE SUMMARY

European Parliament

Research for TRAN Committee – Environmental challenges through the life cycle of battery electric vehicles

KEY FINDINGS

- The literature review indicates broad agreement that battery electric vehicles (BEVs) tend to exhibit significantly lower life cycle greenhouse gas (GHG) impacts than internal combustion engine vehicles (ICEVs), despite initially higher manufacturing emissions.
- This study's life cycle assessment (LCA) modelling indicates that a typical current BEV car already saves over ~60% kgCO2eq compared to an equivalent conventional gasoline car in average EU conditions. Significant life cycle GHG emissions reductions were also found across different situations and countries.
- Analysis of the future outlook shows that, by 2030, average BEV GHG impacts in the EU27 could be 78% lower than those of an equivalent conventional gasoline car (and reach 86% lower by 2050).
- Decisive EU policy action will be needed to maximise BEV benefits and mitigate risks, including an ambitious policy agenda around circular economy approaches for vehicle components (especially batteries) and further research in battery technology.
- Tailpipe CO2 emissions regulations provide a suitable regulatory framework. However, LCA reporting should be encouraged.
- Incentives for right-sized BEVs/batteries may be needed as BEVs consolidate their market position.

Introduction

The European Green Deal and Fit for 55 initiatives have resulted in a substantial revision of the regulatory and policy landscape at EU level on the environmental performance of road vehicles. Key policy initiatives and legislation are the Industrial Strategy, the Circular Economy Action Plan, the proposed Batteries Regulation, the revision of the End-of-Life Vehicles Directive (ELV), the EU Emissions Trading Scheme revision proposal and the revised regulation on CO_2 emissions standards for cars and vans, among others – see Figure ES1.

The present document is the executive summary of the study on Environmental challenges through the life cycle of battery electric vehicles. The full study, which is available in English can be downloaded at: https://bit.ly/3ZbZCQG

Policy Department for Structural and Cohesion Policies
Directorate-General for Internal Policies
Author: Nikolas HILL, Marco RAUGEI, Aleix PONS, Nikos VASILEIADIS, Hugo ONG, Lorenzo CASULLO (Ricardo)
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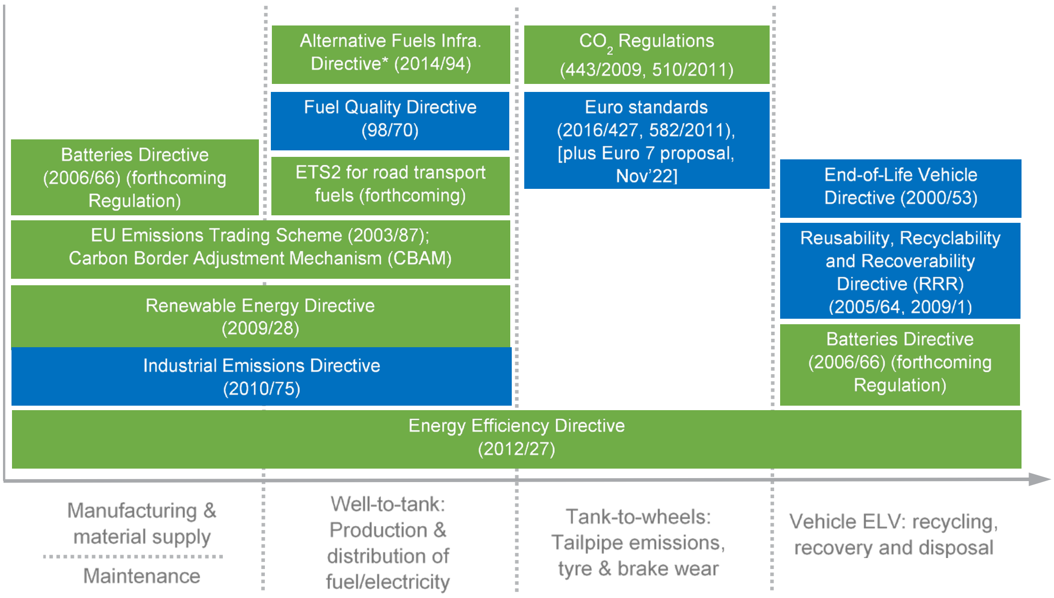
Figure ES1: Simplified mapping of key European legislation to vehicle life phase



Source: Ricardo (own elaboration.)
Notes: Additions/updated proposals in 2021 / Fit For 55 legislative package highlighted in green.

The take-up of BEVs is expected to be the main mechanism for achieving the CO_2 regulation for passenger cars. However, BEVs are only zero emission at their point of use, and a range of policies need to work synergistically to ensure overall reductions in environmental impacts across the full life cycle. Life cycle assessment (LCA) is a methodology that can provide a more complete analysis as it covers environmental impacts arising from production of raw materials and components, vehicle use, production and supply of fuel/energy, and vehicle end-of-life including recycling and reuse.

This study provides the TRAN Committee with an up-to-date expert assessment and comparison between the life cycle's carbon footprint of BEV and ICEV passenger cars, for the current and future perspective (based on policy and technological development). Other life cycle environmental impacts are also discussed where relevant.

Literature overview

An extensive literature review and harmonisation effort was carried out on ICEV and BEV LCAs, comprising industry and independent reports and scientific papers.

The results clearly indicated that BEVs are characterised by higher GHG impacts during the production phase, largely due to the battery packs. However, this initial disadvantage is then significantly overcompensated by lower GHG emissions during the use phase. A large variability was seen in results from the literature, which was most significantly due to the assumed use phase electricity grid mix.

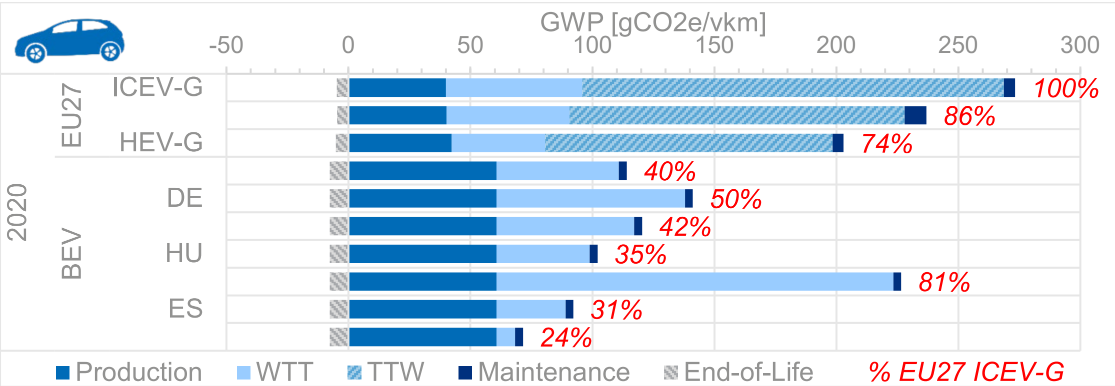
The review also highlighted research and knowledge gaps, among which notably: end-of-life impacts and mitigation strategies (including new recycling processes, and possible second life battery scenarios); supply risk and environmental and social impacts relating to the growing demand for critical raw materials; future evolutionary trends in the battery technology mix.

Current and future outlook for the comparison of ICEVs and BEVs

Ricardo selectively updated the LCA modelling of passenger vehicles, previously developed for DG CLIMA (Hill, et al., 2020), to better reflect both the current situation and the future modelling to better align this with the EU's Fit for 55 package. This analysis provided a quantitative assessment of the potential influence of a range of elements on the life cycle GHG emissions of ICEVs and BEVs.

The analysis complements the literature review and found that BEV passenger cars are expected to already reduce GHG impacts by over 60% in the EU27, compared to gasoline ICEVs (Figure ES2). The analysis also found equally significant GHG savings potentials for most of the other geographies/situations explored. Analysis of the future potential (i.e. to 2030 and beyond), factoring in technology and policy impacts, showed very significant benefits for all countries assessed, due in particular to a cleaner electricity mix (GHG impacts of BEVs up to 78% and 86% lower than ICEVs, respectively by 2030 and 2050) (Figure ES3).

Figure ES2: Regional variations in life cycle GHG impacts for a Lower Medium Car (i.e. C-segment; VW Golf or similar), 2020, EU27, selected EU countries



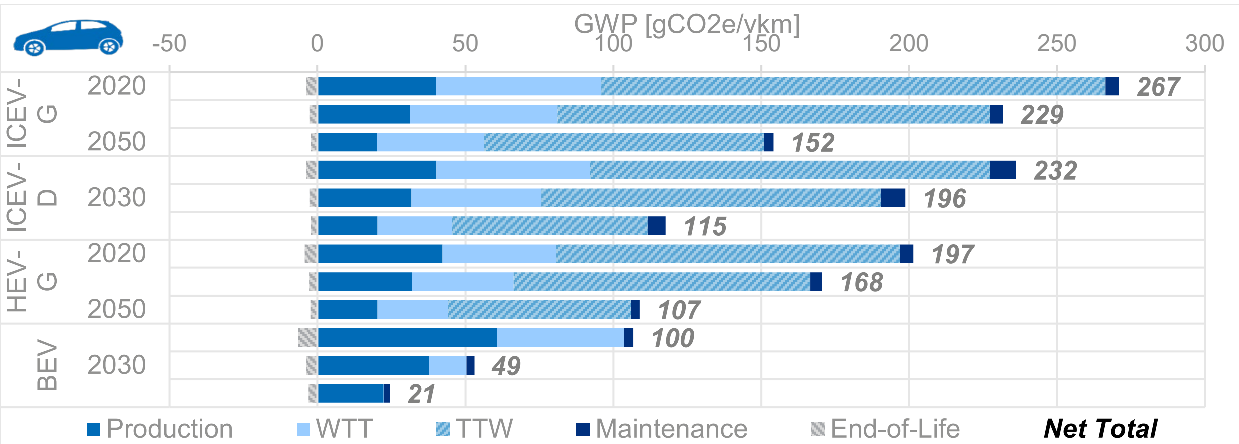
Sources: Life cycle impacts calculated by Ricardo, January 2023.

Notes: ICEV-G/D = gasoline/diesel internal combustion engine vehicle, HEV-G = gasoline hybrid electric vehicle. Production = production of raw materials, manufacturing of components and vehicle assembly; WTT = fuel/electricity production cycle; TTW = impacts due to vehicle operation emissions; Maintenance = impacts from replacement parts/consumables; End-of-Life = impacts/credits from collection, recycling, energy recovery and disposal. GWP = Global Warming Potential. DE=Germany, GR=Greece, HU=Hungary, PL=Poland, ES=Spain, SE=Sweden.

The study also assessed sensitivities of the results to a number of other key parameters, including lifetime km, ambient temperature and electric range/battery size and improvements. These showed that the overall findings, were not significantly affected.

A comparison of alternative low carbon fuel/energy options for gasoline ICEVs and BEVs also highlighted that it is likely that large scale deployment of e-fuels or biofuels in road transport will still have higher emissions than a move to BEVs.

Figure ES3: Current and future life cycle GHG impacts for a Lower Medium Car, EU27



Sources: Ricardo LCA modelling, January 2023.

Policy recommendations

The current and expected policy framework was compared against the findings of the LCA. Results clearly show that the revised target on tailpipe CO_2 emissions, which promotes an accelerated transition to zero-emission vehicles (predominantly BEVs), is expected to lead to significant net GHG emission reductions on a life cycle basis across the EU.

Legislation on vehicle manufacturing and end-of-life, along with energy transition policies are compatible with a scenario in which BEVs offer a clear decarbonisation pathway for road passenger vehicles from the life cycle perspective, well beyond the decarbonisation potential of ICEVs (even when using sustainable fuels, such as e-fuels).

However, decisive policy action on some specific issues will be needed to maximise the benefits of BEVs and mitigate existing risks. The following policy recommendations were derived:

- Develop an ambitious policy agenda around battery recycling and circular economy concepts for critical raw materials. The combined effectiveness of the Battery Regulation and revised ELV Directive needs to be closely monitored to ensure these instruments deliver on policy goals. Particular attention should be given to enforcement, monitoring methods and targets in view of potential market and technological innovations in the next years.
- Tailpipe CO_2 emissions regulations provide a suitable regulatory framework, considering current technical limitations for a regulation on a life cycle basis and the complementary legislation to regulate upstream and end-of-life emissions. However, harmonised LCA reporting should be encouraged to improve the effectiveness and transparency of mitigation measures across life cycle stages.
- As BEVs consolidate their market position, incentives to promote right-sized BEVs/batteries may be needed, for example, in terms of energy efficiency targets for BEVs or for zero-emission vehicles more widely.
- Further EU-wide research may be needed to foster innovation in the field of battery technology, and particularly on more materially-efficient battery variants that utilise smaller amounts of critical elements per unit of energy storage.
- A wider set of policies, including policies to promote a modal shift towards sustainable travel modes and the adoption of mobility-as-a-service, will continue to be relevant to further reduce emissions on a passenger-km basis.

Further information

This executive summary is available in the following languages: English, French, German, Italian and Spanish. The study, which is available in English, and the summaries can be downloaded at: https://bit.ly/3ZbZCQG

More information on Policy Department research for TRAN: https://research4committees.blog/tran/

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Research administrator: Davide PERNICE Editorial assistant: Mariana VÁCLAVOVÁ
Contact: Poldep-cohesion@ep.europa.eu
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