

Social life cycle assessment of battery electric vehicle following ISO 14075 standard

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EXTENDED ABSTRACT

Beginning with a meticulous examination of the social ramifications inherent in Battery Electric Vehicle (BEV) lifecycles, this study delves into the complexities of sustainable mobility from a social sustainability perspective. As global momentum shifts towards the decarbonisation of the transport sector, BEVs have emerged as a cornerstone of clean mobility strategies. However, while environmental and economic dimensions of BEVs are widely studied, the social impacts spanning labour rights, community well-being, and ethical governance remain less explored. This research seeks to bridge that gap through a comprehensive Social Life Cycle Assessment (S-LCA), following the ISO 14075 standard, offering a structured and systematic methodology to assess social performance across a vehicle's entire life cycle. The assessment is centred on a detailed case study of a German-manufactured Battery Electric Sport Utility Vehicle (SUV), chosen for its relevance to both European and global automotive markets. In addition to the case-specific investigation, the study incorporates an extensive literature review to contextualise findings within existing research and to identify persistent knowledge gaps. The S-LCA framework used is grounded in the UNEP-SETAC guidelines and enhanced through the use of OpenLCA software in combination with the Product Social Impact Life Cycle Assessment (PSILCA) database, a widely accepted tool and database for quantifying social risks across global supply chains. This integration facilitates both the modelling of life cycle stages and the identification of regional and sector-specific risk indicators, providing a robust basis for empirical evaluation.

The research systematically categorises social impacts across key stakeholder groups, namely Workers, Local Communities, Consumers, and Society at large. These categories align with internationally recognised standards and enable a holistic understanding of how various social dimensions interact with technical and supply chain processes. The scope of the assessment spans all phases of the product life cycle—from raw material extraction, material processing, and manufacturing, through distribution and vehicle use, to eventual disposal and recycling. This full-spectrum approach ensures that no phase is overlooked and that cumulative social burdens are appropriately accounted for. One of the primary contributions of this study is the development of a clear, reproducible procedure for conducting an S-LCA. The procedure includes goal and scope definition, inventory analysis, impact assessment, and result interpretation—each phase being tailored to capture social criteria specific to the BEV context. The inventory analysis stage identifies the material composition of the vehicle, supplier origins, and transportation logistics, while the impact assessment quantifies potential risks using PSILCA indicators such as child labour, gender wage gap, occupational hazards, and corruption indices. The interpretation phase consolidates these findings, contextualising them within the broader implications for sustainability policy and industry practice. Key findings from the assessment reveal significant social sustainability challenges in the upstream phases of the BEV supply chain, particularly during raw material extraction and manufacturing. Elements such as cobalt, lithium, and nickel critical for battery manufacturing are frequently sourced from regions marked by severe socio-political instability and weak regulatory frameworks. The study identifies high-risk zones, where forced and child labour are prevalent in mining and manufacturing operations. Similarly, other regions, where hazardous working conditions and gender-based wage disparities are commonly reported within resource-extractive sectors are also identified. These issues underscore the ethically problematic origins of many materials that underpin the clean mobility revolution. The analysis also reveals social risks during the operational phase of the BEV, particularly related to the electricity generation sector. In the German context, despite progressive energy policies, a significant share of electricity still originates from fossil-intensive sources imported or traded through countries with questionable governance records, including Poland, the Czech Republic, and Russia. The study highlights governance-related risks such as corruption, bribery, and anti-competitive behaviour within energy and utility sectors, which in turn influence the overall social footprint of BEV usage. Although the end-of-life and distribution stages of the BEV life cycle exhibit relatively lower overall social impacts, they are not devoid of concern. The interpretation phase of the S-LCA provides nuanced insights into risk variability under different

scenarios. For instance, increased medium-risk hours are observed in scenarios where the vehicle's material inputs originate from multiple countries with inconsistent social performance ratings. High-intensity usage patterns, such as frequent rapid charging and high-speed driving, were also associated with higher energy demands and thus greater exposure to the social risks embedded in electricity supply chains. These findings emphasise the dynamic nature of social impacts, which can vary significantly based on consumer behaviour, sourcing strategies, and geopolitical developments. Key recommendations include the implementation of supplier auditing systems, increased traceability through blockchain-based tracking technologies, and strengthened enforcement of social compliance through international trade agreements. The study also advocates for consumer-oriented policies such as social labelling schemes to promote ethical purchasing decisions. In conclusion, this research offers a critical contribution to the field of sustainable mobility by foregrounding the social dimensions of BEV production and usage. It presents a replicable S-LCA framework, validates it through a real-world case study, and draws attention to both high-risk zones and overlooked lifecycle phases. By doing so, it supports policymakers, manufacturers, and researchers in identifying priority areas for intervention. The findings reinforce the urgent need for coordinated global action to enhance labour protections, bolster governance mechanisms, and promote equity and justice in clean technology transitions. As the automotive industry pivots towards electrification, ensuring that this transition is not only environmentally sustainable but also socially responsible is imperative for long-term success.