A Systematic Review of Greenhouse Gas Emissions from Battery Electric Vehicles: A Life Cycle Assessment Perspective

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ABSTRACT

The electrification of the transportation sector is frequently proposed as a primary strategy for decarbonization; however, its effectiveness is intrinsically linked to the carbon intensity of the local electricity grid. This study presents a systematic literature review (utilizing the PRISMA method) of 39 recent life cycle assessment (LCA) studies to evaluate the greenhouse gas (GHG) reduction potential of passenger battery electric vehicles (BEVs) under varying energy mixes. Results indicate that the production phase contributes 12–33% of lifecycle emissions, primarily driven by battery manufacturing, creating a carbon debt that must be offset during operation. The operational phase (60–90% of total emissions) exhibits high sensitivity to grid composition. The review reveals a critical divergence: while BEVs charged by renewable-dominated grids (e.g., Sweden) achieve up to 60% emission reductions compared with internal combustion engine vehicles (ICEVs), they may generate higher emissions than hybrid electric vehicles (HEVs) in fossil-fuel-dependent regions such as the Middle East and parts of Asia. Specifically, in regions with a grid intensity exceeding approximately 700 g CO_2/kWh, HEVs currently offer a more effective immediate pathway for emission reduction. This study concludes that for developing economies, a dual strategy of transitional hybrid adoption alongside aggressive grid decarbonization is essential to realize the environmental benefits of electric mobility.

Keywords: Battery Electric Vehicle (BEV), Greenhouse Gas Emission, Life Cycle Assessment, Transportation, Energy Decarbonization

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