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Circular Compliance: Aligning EV Battery Waste Management with the EU Battery Regulation 2023/1542

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Abstract.

The rapid growth of electric vehicle (EV) adoption in Europe presents both opportunities and challenges for sustainable energy transitions. A critical issue lies in the management of end-of-life (EoL) batteries, which contain scarce and hazardous materials yet offer high potential for recovery and reuse. The EU Battery Regulation 2023/1542 establishes ambitious provisions, including mandatory recovery rates of 70% lithium and 95% cobalt/nickel by 2030, carbon footprint disclosure, digital battery passports, and extended producer responsibility (EPR) schemes. This study evaluates how circular economy strategies can align with these requirements to ensure sustainable EV battery waste management. A policy–technology mapping framework was developed to analyze compliance potential across four strategies: design-for-circularity, second-life applications, recycling innovations, and material recovery optimization. Results indicate that recycling innovations and material recovery achieve the highest regulatory alignment, with hydrometallurgical processes currently reaching 90–95% cobalt/nickel recovery and projected 70% lithium recovery by 2030. Design-for-circularity reduces lifecycle impacts by 15–20%, while second-life applications extend battery utility by 20–30% and lower lifecycle carbon emissions by 10–15%. A national case study of Italy reveals accelerating EV adoption (>25% annual growth) but highlights limited recycling capacity, with only 30% of EoL batteries processed domestically, underscoring urgent infrastructure needs. The findings demonstrate that no single strategy ensures full compliance, but integrated approaches combining modular design, advanced recycling, and second-life deployment can deliver both regulatory compliance and sustainability benefits. This framework provides actionable insights for policymakers and industry stakeholders, strengthening Europe's pathway toward a circular, low-carbon mobility system.

Keywords: EU Battery Regulation 2023/1542, Circular Economy, EV Battery Recycling, Second-Life Applications, Material Recovery