

Abstract

The Cobalt Supply Chain and Life Cycle Assessment of Lithium-ion Battery Energy Storage Systems

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Lithium-ion batteries (LIBs) deployed in energy storage systems (ESS) can reduce the carbon intensity of the electricity generating sector. LIB demand is likely to continue to grow, requiring additional raw materials. Impacts from the upstream processes needed to convert raw materials into battery components are not fully understood. The aim of this study is to use life cycle assessment (LCA) modeling, using the OpenLCA platform and data from public and private sources, to quantify environmental impacts along the full supply chain for cobalt, a crucial component in many types of LIB. The LCA will quantify the cradle-to-grave impacts for a number of standard impact pathways, including global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), and others that are attributed to the mining, extraction, refining of cobalt products for LIBs, as well as the use and disposal of the LIBs. We assume a 30-year modeling period and include LIB replacement. Three refinery locations, a range of ore grades, two energy options (wind and solar), and three battery chemistries (NCA, NMC111, and NMC811) are modeled to better understand their effect on the life cycle impacts. The results show that impacts begin to increase non-linearly as ore grade drops below 2%; refining outside of China can reduce GWP by over 12%; the impacts for NCA and NMC811 batteries are 63% and 74% lower than NMC111, respectively; and the impacts associated with pairing an NMC811 battery with wind generation are 32% less than with solar. The results shed light on which processes in the LIB cobalt supply chain are most environmentally impactful, how these impacts vary across different scenarios, and what can be expected with time, as wind and solar electricity generation increases. This research will help the energy industry understand cobalt supply chain processes and ways to reduce environmental burdens of LIBs. Policy makers and the private sector can use this work to identify locations to direct further investment.

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