Quantification of Environmental Impacts Associated with the Full Life Cycle of the Global Nickel Supply Chain

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The global energy transition has been accelerating recently in many ways. To achieve ambitious goals set by countries and organizations, significant developments in energy infrastructure are needed, requiring a 60-70% increase in demand over next decades for nickel, an important input for stainless-steel (SS) and lithium-ion batteries (LIBs). However, nickel mining and production come at a cost to the environment. This research aims to provide a comprehensive life-cycle assessment (LCA) of global nickel supply chains, expanding beyond past efforts that have focused only on sulfidic ore bodies or limited environmental parameters. Here, we also assess laterite ore bodies, 11 variations in ore grade, 64 nickel supply routes, four processing technologies (i.e., HPAL, Caron, pyrometallurgy, POX), and three nickel products (nickel sulfate, nickel metal, and ferronickel). In total, we consider cradle-to-grave system boundaries for 704 unique scenarios. In each case, we use one tonne of nickel content, incorporated into either SS or LIBs in wind turbines, as a functional unit. The inventory was compiled from mass-balance sheets, company reports, Ecoinvent (v3), and then processed in OpenLCA software. Life cycle impacts were assessed for 16 different pathways.

Results showed that impacts of nickel production from laterites are 1-13 times higher than sulfides in 11 out of 16 impact pathways. As the ore grade drops below 1.3% Ni, emissions begin to increase non-linearly for all impacts. We found that, as ore grade decreases, relative impact of diesel versus electricity for mining, processing and refining increases from 5% up to 54%, when most emissions stem from the mining stage and less from processing. Similarly, land use increases by 18.7-fold as ore grade decreases from 2.6% Ni to 0.1% Ni. Results showed that pyrometallurgy was the most emission-intensive route for laterite and sulfide ore processing for most environmental pathways studied. This research will help policy makers and private sector identify ways to reduce environmental burdens related to nickel supply chain.