Honduras nickel-manganese-cobalt batteries nmc

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We recently identified two LIB constituents--the active cathode material and aluminum--together with energy use for cell assembly as key contributors to the cradle-to-gate energy and environmental impacts of LIBs. Moreover, we found that the LCA results for LIB depend to a large extent on the battery supply chain. The high energy demands for producing battery materials and constructing the cells make the energy and environmental impacts susceptible to electricity mix and heat sources, as well as battery material mining and refining activities, which exhibit considerable variations across geographic regions (Dai et al. Submitted).

This study uses the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET(R)) model to determine the effect of changes to the regional conditions of battery production on the energy and environmental impacts of batteries. In particular, the study considered multiple electrical grid profiles for the production stages of several materials. The materials and stages in question are presented in Fig. 1, and the scenario parameters are provided in Table 3 in the Appendix to this report. The materials and stages were chosen on the basis of their known influence on LIB energy and environmental impacts. Here, the baseline conditions are consistent with the 2018 release of GREET (see Table 3 for description).

Battery materials and stages under consideration in the present study

The GREET model (Argonne National Laboratory 2018c) currently uses a US-centric material and production supply chain for NMC111, so this was modified to account for the globally regional variability of production for nickel, aluminum, cobalt sulfate, NMC111, battery cell assembly, and the battery management system (BMS). This was done by accessing the GREET processes for each of the noted materials or products and modifying the underlying calculations to utilize different electricity grid profiles, process emissions assumptions, and energy source profiles, depending upon the process. The following sections describe the conditions considered along with the impetus for that consideration.

Total life-cycle energy associated with the production of NMC111 LIB using the baseline GREET2018 conditions

Total life cycle GHG emissions associated with the production of NMC111 LIB using the baseline GREET2018 conditions

Life cycle SOx emissions associated with the production of NMC111 LIB using the baseline GREET2018 conditions

Nickel is used in the cathode material for NMC111, typically sourced as nickel sulfate, which itself is produced from refined nickel. Nickel production is an energy-intensive process. It is composed of several stages that can be roughly classified as mining, beneficiation, primary extraction, and refining. These are the stage definitions within GREET, but the true nickel production process contains many stages within each of the broader classifications provided above. GREET uses these broad classifications to describe the energy and material requirements into and emissions out of each stage. GREET can then determine the total energy and material inputs of nickel production, and return the total pollutant emissions generated and water consumed.

We varied both the electricity profile assumed for the refining stage of nickel production and the sulfur dioxide emissions for that stage. Table 4 presents the assumed electricity profiles. Table 5 presents the sulfur dioxide emissions associated with the refining stage for the three profiles, based on Benavides et al. (2015).

In GREEET2018, the BMS includes other electronic parts which are modeled as a circuit board and semiconductor (Argonne National Laboratory 2018a). In GREET2018"s baseline conditions, the BMS production occurs in the US and constitutes 9.1% of the LIB"s life cycle energy consumption. Here, we examined the effects of BMS production in the US, China, Japan, Korea, and Europe, and scenarios when electricity was sourced from coal only, solar and wind only, or hydroelectric power only, as detailed in Table 3.

Water consumption associated with NMC111 LIB production via different supply chains

We evaluated the production of NMC111 batteries considering the supply chains of the US, China, South Korea, Japan, and Europe. Regionalized (country/region-specific) conditions were used for the production parameters. However, some production parameters were not regionally specific in this analysis. In particular, CoSO4 production occurred in China due to Chinese market dominance in this material"s production. Table 3 (individual country scenario) details the parameters for each scenario.