Lithium ion battery 590 kWh

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Life cycle assessment (LCA) literature evaluating environmental burdens from lithium-ion battery (LIB) production facilities lacks an understanding of how environmental burdens have changed over time due to a transition to large-scale production. The purpose of this study is hence to examine the effect of upscaling LIB production using unique life cycle inventory data representative of large-scale production. A sub-goal of the study is to examine how changes in background datasets affect environmental impacts.

Upscaling LIB production shifts environmental burdens to upstream material extraction and production, irrespective of the carbon intensity of the energy source. Thus, a key message for the industry and policy makers is that further reductions in the climate impacts from LIB production are possible, only when the upstream LIB supply chain uses renewable energy source. An additional message to LCA practitioners is to examine the effect of changing background systems when evaluating maturing technologies.

The purpose of the study is to examine the effect of upscaling LIB cell production from an environmental life cycle perspective. To accomplish this, we model and compare production in a small-scale and a giga-scale factory. The small-scale factory is modelled based on the work previously published by Ellingsen et al. (2014), and the giga-factory is modelled using data compiled from three environmental permit applications and the energy report of a giga-scale battery cell manufacturing facility in Sweden (Northvolt 2020, 2019, 2018, 2017). By providing new inventory data representing the high-end for material and energy use values, but with a potential for reductions, the analysis indicates a bottom reference level for environmental impacts of large-scale LIB cell production.

We adopt the original small-scale factory, which was modelled by Ellingsen et al. (2014) using Ecoinvent v2.2 background datasets, to the latest Ecoinvent v3.7.1 database for comparability with the giga-factory. Updates to background datasets represent better data availability and progress in the real-world industrial activities. Thus, another sub-goal of the study is to understand how changes in background datasets affect environmental impacts. The foremost intended audience of this study are LIB production industry and policy makers driving action towards decreasing environmental burdens from battery production. The study also aims to inform LCA practitioners modelling and analyzing LIBs.

Boundaries defined between the background, intermediate and foreground systems for the Giga-3.7 model of large-scale LIB production. Note: The "Cell factory construction and operation" unit process is a factory wide support process, and the schematic shows how the unit process is linked into the model

Next, the impact assessment is carried out using the ReCiPe midpoint method with a Hierarchist perspective (Huijbregts et al. 2017). Refer to the Sect. S6 of the SI for more details on impact indicator types and descriptions. Specific attention is given to global warming, acidification, and human toxicity in the main article. Complete impact category results are reported in Sect. S6 of SI. Resource use, an area of attention for sustainability of LIBs, is analyzed using two different LCIA methods for mineral resource scarcity: the surplus ore method included in ReCiPe and the crustal scarcity indicator (Arvidsson et al. 2020a, b).

The second highest share of electricity demand comes from overall factory operations and utilities, i.e., approximately 18% -- of which 26 MJ/kWh is used by the dry room. Dry rooms are throughput independent and sized according to maximum factory capacity. This electricity requirement for the dry room in this study is in accordance with other published values in literature for large-scale LIB production (Dai et al. 2019; Sun et al. 2020).

The total heat demand in the giga-factory is about 27 MJ/kWh. This is mainly due to dry rooms, which in addition to their electricity use account for over 90% of the total heat demand (Northvolt 2020). This includes maintaining an atmosphere with moisture content lower than 100 ppm in the operational areas (Ahmed et al. 2016). This is the reason cell production processes such as cell assembly and formation cycling are carried out in "dry rooms" (Dunn et al. 2015a).

The LCA study of a small-scale factory by Ellingsen et al. (2014) was replicated and analyzed using both Ecoinvent v2.2 and v3.7.1 data (Fig. 2: Small-2.2 and Small-3.7, respectively). This modification of the background system resulted in an increase of the global warming impacts from about 140 to 185 kg CO2-eq./kWh. Changes to the cobalt sulfate production data accounted for more than half of the increase in impacts, followed by copper foil production and electricity generation in the reference scenario (South Korean electricity mix).

Comparison of global warming impacts for the small-scale factory modelled using different Ecoinvent versions (with recycled content), i.e., version 2.2 originally used by Ellingsen et al. (2014), and the latest version available at the time of the study

Global warming impacts for the two factory models in the different carbon intensity scenarios