ASTRABAT

HOW TO ENSURE ASTRABAT CELL SUSTAINABILITY?

Eco-design and LCA studies have been carried out to address the need to enhance the sustainability of lithium-ion batteries by reducing its carbon footprint and other environmental impacts. The studies also address the use of critical raw material for batteries.

Ensuring the environmental and economic sustainability of the novel cell developed by ASTRABAT is one of the project's main objectives. For this reason, the partner LOMARTOV has worked on a report to provide eco-design recommendations in support of the decision-making process on the compounds and processes that can be used in the ASTRABAT battery to enhance its environmental profile.

The methodology

A tailored environmental screening of compounds (LLZO, lithium-based salts and ionic liquids, among others) and manufacturing processes was used.

The methodology applied was the streamlined Life Cycle Assessment (LCA). This follows a quantitative life-cycle approach built on simplifying the LCA methodology. A complementary functional analysis methodology was used whenever possible to link the environmental assessment with the functional parameters of an electrochemical cell. Lastly, a preliminary "cradle-to-gate" LCA of the ASTRABAT battery was performed to more accurately analyse the main hotpots to tackle during the scaling-up process of the cell production.

The results

This study has successfully guided the battery developers towards more environmentally-friendly components and manufacturing processes to design ASTRABAT GEN #2D cell. The use of FSI and TFSI lithium-based salts and ionic liquid has been recommended due to their lower environmental impact and their good behaviour versus other studied salts. Aqueous-based manufacturing processes should be prioritised for the anode formulation, and the two different cathode manufacturing approaches have been evaluated to guide a sustainable scale-up of the process. At lab-scale, Daikin process exhibits better environmental performance, which is mainly attributed to the reduction of glove box/dry room usage.

The anode and cathode drying are the processes contributing the most to the carbon footprint of the battery, since they are the most energy consuming steps. These phases should be optimised when upscaling, so a tailored procedure of drying is being developed to reduce the energy consumption. Like commercial LIB, the copper used as current collector and the use of NMC are among the main components causing an impact in mineral resource consumption. In any case, the main hotspots identified in the ASTRABAT design are the same ones that contribute the most to the conventional liquid LIB as well. Even if the study determines that the ASTRABAT impact is higher than for conventional LIB, this should not hamper ASTRABAT industrialisation and marketability since the ASTRABAT processes are lab-scale ones, which are far from being as optimised as the commercial ones. ASTRABAT still needs to be scaled up to similar processes used in the industry, which will involve substantial optimisation in resource use and hence environmental impact reduction.

It has been highlighted that additional processes and materials used in ASTRABAT cell design present an additional risk, either in terms of energy consumption or other environmental aspects that are not usually reported. The anolyte curing process has been established as an additional critical step to be addressed during the scale-up phase and subsequent industrialisation, for example, by studying alternative curing processes which are less energy-demanding, like UV curing. LLZO is also one of its main drivers of mineral resource use, which is important to mention since it is an addition to the new generation of ASSB. Another new element used in ASTRABAT which is not present in the commercial cells is ORMOCER®, which has a strong potential for ozone depletion. This should be carefully managed during the industrialisation and recycling of the ASTRABAT battery to avoid release of its reactants or derivatives to the atmosphere.

Compared to other existing industrialised batteries, the ASTRABAT design still needs further optimisation when scaling-up to be competitive in the market. Positively, when compared to other lab scale developments, either conventional LIB or SSB battery developments, the impacts of ASTRABAT are in the same range. Therefore, it is likely that the optimisation, once the new manufacturing methods are more developed and scaled up, leads to more competitive ASSB batteries in environmental terms as well.

Additional challenges have been identified in the industrialisation of the ASTRABAT battery, such as quality control of the electrodes and purity of the raw materials needed. Besides, new manufacturing methods should be developed to address solid state challenges like the electrolyte impregnation, mainly when ceramics are part of it. Further standardisation in battery packs and their disassembly have been identified as a key element to increase circularity besides recycling.

A final LCA study of the ASTRABAT cell will be performed, covering both the environmental and economic profile, as well as a recyclability analysis considering both pyrometallurgical and hydrometallurgical routes.

Conclusions

This study serves as guidance for the industrialisation phase of ASTRABAT cell, identifying the hotspots and bottlenecks that should be further studied and optimised. Beyond these uncertainties, it is highly relevant for the development of the batteries of the future to consider sustainability requirements from an early stage of the research, paving the way for a sustainable battery value chain.

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