Application of LCA and S-LCA to Low-TRL Technologies: A Case Study of a Novel Current-Limiting Solution for the Energy Transition.

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Abstract: Low-voltage Direct Current (LVDC) power systems are increasingly recognised as a key enabler of a clean and efficient energy transition, particularly for decentralized generation and storage applications. Despite their technical and operational advantages, safety concerns—especially related to fault current management—continue to limit their widespread adoption. The NOVETROL project (NOVEL CURRENT CONTROL FOR CLIMATE NEUTRAL ENERGY INFRASTRUCTURE, Grant Agreement No. 101192615) addresses this critical barrier by developing innovative current-limiting (CL) technologies based on high-mobility materials exploiting the extraordinary magnetoresistance (EMR) effect. The project further aims to integrate these solutions into both Direct Current (DC) and hybrid AC/DC energy systems.

To ensure a comprehensive sustainability assessment, the project employs both Life Cycle Assessment (LCA) (ISO, 2006; ISO., 2006) and Social-Life Cycle Assessment (S-LCA) (UNEP, 2020), two internationally recognised methodologies for evaluating environmental

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impacts and socio-economic risks across the entire life cycle of a technology. The LCA study focuses on quantifying environmental impacts associated with the production of current-limiting devices, identifying key hotspots and opportunities for impact reduction, including strategies related to material efficiency and the use of recycled content. In parallel, S-LCA is employed to assess social risks along the supply chain, with particular attention to affected stakeholders and issues related to labour conditions, occupational health and safety, and broader socio-economic implications..

The combined application of LCA and S-LCA allows for a multidimensional understanding of the sustainability performance of the proposed CL technologies. Preliminary findings indicate the presence of key environmental hotspots linked to material extraction and manufacturing processes, highlighting areas where targeted improvements can significantly reduce the overall environmental footprint, also implementing circular economy principles. Similarly, the S-LCA analysis identifies critical supply chain stages where social risks are more pronounced, enabling the prioritisation of mitigation strategies and stakeholder engagement.

The integration of LCA and S-LCA within the NOVETROL project provides a robust framework for the systematic evaluation of both environmental and social dimensions of emerging LVDC technologies. By addressing both technical and sustainability challenges, NOVETROL contributes to enhancing the feasibility and acceptability of LVDC systems, facilitating their transition toward large-scale deployment.

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