REPAIR FOR HIGH-VOLTAGE ELECTRIC MOTORS: ENERGY EFFICIENCY VS RESOURCE USE?

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Electric motors in the industry represent 69% of the industrial electricity consumption in Europe. Even if few in number, high voltage (HV) motors represent a significant share of this consumption due to their more intensive use and high output power. Two main HV motor technologies exist: induction motors (IM) and synchronous motors (SM), of which the latter are more energy efficient. Improving energy efficiency as well as use extension by maintenance, repair or remanufacturing have been identified as relevant circular economy strategies for improving the environmental performance of such active and durable products. However, the assessments performed focus on small- and medium-size electronic products, leaving out bigger products that are more durable and more energy consuming such as HV motors.

Those motors are often used until failure, which frequently occurs in stator windings, and which could be repaired by rewinding at the expense of a slight decrease in efficiency. However, other use extension strategies such as reuse and remanufacturing are hindered by the customization of HV motors to their specific use. Finding an appropriate set-up for a second use is difficult for such motors and it is therefore performed seldom. The aim of this study is to compare the life-cycle environmental impact of lifetime extension by repair for the two motor technologies in comparison to their replacement.

For each motor technology, two scenarios are explored. The motor is used for 20 years with a low-carbon electricity mix, and an additional 10-year use is provided by either 1) replacement with a new similar motor or 2) repair by rewinding. Additionally, for the IM, a third scenario with the replacement with a SM is explored. For each scenario, a cradle-to-grave LCA is performed for global warming (GW) and for mineral resource depletion with the crustal scarcity indicator (CSI). The avoided burden approach is used for end-of-life modelling: material inputs are modelled with primary production and recovered materials are assumed to displace primary production. The rewinding is modelled with the recycling of the old stator winding, the production of a new winding and a small decrease in efficiency.

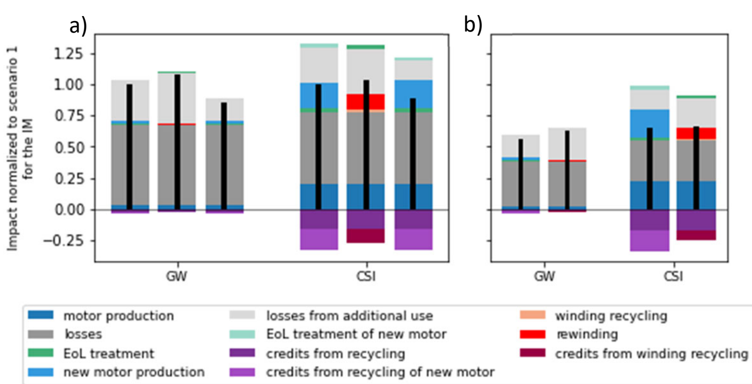

Figure 1 - LCA results for a) scenario 1, 2 and 3 (left to right) for the IM and b) scenarios 1 (left) and 2 (right) for the SM.

Results show that energy losses during use phase are dominant for both GW and CSI (Figure 1). For the latter, it is due to both uranium use for nuclear energy production and to copper use in transmission lines. Moreover, credits from recycling are relatively high for the CSI as HV motors are made of metals (steel and copper) with high recycling rates. Thanks to its higher efficiency, the SM motor has a better environmental performance than the IM. The rewinding process is less impactful than producing a new motor. However, due to the reduced efficiency after repair, the higher losses during the extended motor use offset the gain from avoiding the production of a new motor. For both motor technologies, replacement with a new motor, and especially with the more efficient SM, is preferred from an environmental point of view compared to repair.

This study shows that due to the long lifetime and high energy requirements of HV motors the energy efficiency is an essential factor for the life-cycle environmental performance. Choosing and maintaining high energy efficiency is key in this situation, especially for repair to be beneficial over product replacement. The conclusions also point to the importance of the allocation of resources to electricity production and transmission. Resources used in background productions become as important as the ones in the product under study in the life-cycle performance for resource depletion.