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Trade-offs Between Use-Phase Efficiency and Environmental Footprint: Recycled Nd-Magnets in Washing Machines

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Objectives
The widespread proliferation of Electrical and Electronic Equipment (EEE) has intensified the challenges associated with managing Waste Electrical and Electronic Equipment (WEEE), particularly regarding the recovery of critical raw materials. Within the framework of the Harmony project, this study focuses on the development of a washing machine drain pump utilizing recycled bonded magnets. The adoption of Neodymium (Nd) magnets in these components is analyzed in the context of the Energy-using Products (EuP) Directive and "Class A++" energy labeling requirements, despite the inherently limited duty cycles of such motors.
Methods
A Life Cycle Assessment (LCA) methodology is employed to compare short-loop and long-loop recycling processes for bonded magnets against primary material production. Furthermore, the study introduces a detailed analytical comparison based on the characterization of operational hours versus total cycle time to accurately quantify the real-world energy consumption of the pump.
Results
The analysis evaluates the differences in consumption associated with Nd-based magnetic solutions to determine their effective impact on the overall energy balance of the appliance. The findings provide a data-driven assessment of the fundamental trade-offs between use-phase energy efficiency and the environmental footprint embodied in the magnetic materials.
Conclusions
This comparison identifies the most sustainable pathway for industrial design by successfully balancing stringent regulatory energy standards with circular economy objectives. Ultimately, the study demonstrates the viability of utilizing recycled magnetic materials to mitigate environmental impact without compromising the functional efficiency of the appliance.

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