POPULAR SCIENTIFIC ABSTRACT

Qiance Liu

Material Flow Analysis based Multidimensional Sustainability Assessment for Resources Circularity: Case of Neodymium

Material Flow Analysis (MFA) is vital for assessing the sustainability of critical materials, such as neodymium (Nd), crucial for vehicle electrification and clean energy. Despite Nd's recognized criticality, its low recycling rate poses a challenge. This study focuses on achieving Nd circularity through multidimensional sustainability assessments, expanding beyond resource-centric MFA. The framework of MFA-based sustainability assessment integrates technological, economic, and engineering aspects across the Nd value chain. Employing dynamic MFA models, patent analysis, and bibliometrics, the study assesses Nd in resource, technological, economic, and recycling dimensions.

The resource assessment from 1990 to 2020 unveils global Nd cycles, emphasizing China's dominance and challenges in end-of-life product recovery. The study identifies significant recycling potential, stressing the need for strategic interventions for sustainable Nd management. Technological and economic assessments reveal the dominance of material flows and innovation throughout the Nd lifecycle. The integration of Material-Value-Technology (MVT) highlights the link between technology, value, and materials, offering insights into global industry evolution. In recycling engineering, key barriers hindering Nd and NdFeB magnet recycling are categorized into resource, product, technological, economic, environmental, and social aspects. Technological innovation emerges as a pivotal solution, prompting proposed countermeasures like promoting advancements and enforcing regulations.

The findings provide crucial insights into the global Nd industry evolution, offering practical implications for achieving Nd circularity. The general MFA-based multidimensional assessment framework can be also expanded to assess diverse dimensions (e.g., environmental or social) and industries for sustainable resource management. Achieving material circularity remains multidimension significant challenges. The study appeals the crucial need for collaboration among diverse stakeholders, including policymakers, industry players, and academia, spanning various regions and countries. Only through enhanced cooperation can the complete circulation of critical materials be realized.