

CAMBIUM

Circular Material flows in Belgium

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SUMMARY

Belgium, like many European countries, faces increasing challenges related to the sustainable management of materials and the resilience of its supply chains. As the transition to a climate-neutral and digital economy accelerates, the demand for strategic materials embedded in technologies such as batteries, photovoltaic systems, wind turbines, electronics, and electric mobility continues to grow. At the same time, global supply chains are becoming more volatile due to geopolitical tensions, market concentrations, environmental constraints and rapidly shifting technological demand. This combination of rising material needs and diminishing supply security has led European and Belgian policymakers to call for more robust monitoring, improved data infrastructures and a deeper understanding of material flows, resource footprints and critical raw material dependencies. The CAMBIUM project was developed in response to these challenges. Its overarching ambition was to design and test a set of methodological tools that enable Belgium to better monitor and understand its material system, with a particular emphasis on the circularity and criticality dimensions. The CAMBIUM project concentrates on developing methodologies that can support long-term monitoring, guide future research and contribute to evidence-based policymaking.

The project pursued two complementary goals. The first was to develop a holistic methodological framework for analysing material flows and material footprints in Belgium. This required mapping and evaluating existing international indicator frameworks, identifying gaps in Belgian data structures, and designing methodological pathways tailored to Belgium's federal and regional governance systems. The second goal was to develop a criticality methodology for identifying materials and product streams that are important to the Belgian economy. This involved adapting European criticality approaches to the Belgian context, improving the capacity to identify materials embedded in imported products and waste streams, and mapping supply-chain vulnerabilities for both materials and technologies of strategic importance.

Methodologically, the project adopted an integrated approach combining economy-wide material flow analysis, life cycle thinking, environmentally extended input-output modelling, multi-criteria criticality assessment and multilayer material system analysis. Extensive reviews were conducted to identify strengths and weaknesses of existing frameworks and to understand how these could be translated into an approach suitable for the Belgian context. In parallel, detailed analyses were carried out for selected materials and technologies to test and refine the proposed

methodologies. The multilayer material system analysis of the Belgian wind turbine fleet, for example, provided a detailed case study that illustrated how material stocks, flows and end-of-life potentials evolve as technologies change over time.

The project produced a range of scientific, methodological and policy-relevant results. It developed a structured analytical framework that allows Belgium to assess material flows and material footprints using consistent and transparent procedures. This framework integrates macro-level indicators aligned with Eurostat's circular economy monitoring systems and micro-level pointers designed to detect short-term changes in critical product flows and supply-chain exposures. The analysis revealed several hotspots in Belgian material use, including high dependency on imports of specific materials that play a central role in renewable energy technologies, electrification and digitalisation, making them increasingly crucial for both industrial competitiveness and the energy transition. The study also identified gaps and inconsistencies in existing data sources, particularly in combining product flow data and waste statistics and composition data for critical raw material rich products, which need to be addressed to strengthen national monitoring capacities.

The methodology for identifying critical raw materials provided Belgium with its first systematic, nationalised approach to assessing material supply risks. By combining Belgian-specific sectoral data, trade data and technological relevance, the project demonstrated that Belgium's risk exposure sometimes deviates from EU averages. For many critical materials, Belgium's dependence on concentrated and geopolitically sensitive supply chains is substantial, but as is its role in producing some of the critical raw materials. The findings support more targeted policy interventions aimed at improving recycling, enhancing recovery infrastructure and diversifying supply chains.

The multilayer material system analysis demonstrated how these methodological advances can be applied to a real-world technology. By analysing Belgium's wind energy installations between 1996 and 2021, the project showed that material stocks continue to accumulate and will generate substantial end-of-life flows in the coming decades. Copper and steel dominate in terms of mass, but rare earth elements and other speciality materials become increasingly important as offshore and direct-drive technologies proliferate. The multilayer material system analysis also identified potential bottlenecks in recycling pathways and highlighted the importance of improving collection, dismantling and recovery practices to maximise the circularity benefits of renewable energy systems.

Together, these scientific results form a robust base for decision support. The developed or improved methodologies offer Belgian authorities the means to evaluate material dependencies, identify emerging risks, and anticipate future material needs. They can also strengthen Belgium's contribution to European processes under the Critical Raw Materials Act and Circular Economy Action Plan. The project recommends that Belgium periodically monitors material flows and critical material dependencies and risks; improve data integration across federal and regional authorities; and promote transparency in supply chains. Strengthening analytical capacity within

public administrations and fostering collaboration across regions, agencies and research institutions will be essential to sustain and expand the methodological advances made by the project.

The CAMBIUM project thus delivers not only scientific insights but also a methodological architecture with long-term value. By enabling a deeper and more systematic understanding of Belgium's material system, it provides the foundation for more resilient, circular and strategically informed resource governance.

Key words

material flows, critical raw materials, circular economy, environmental and social dimensions, value chain perspective