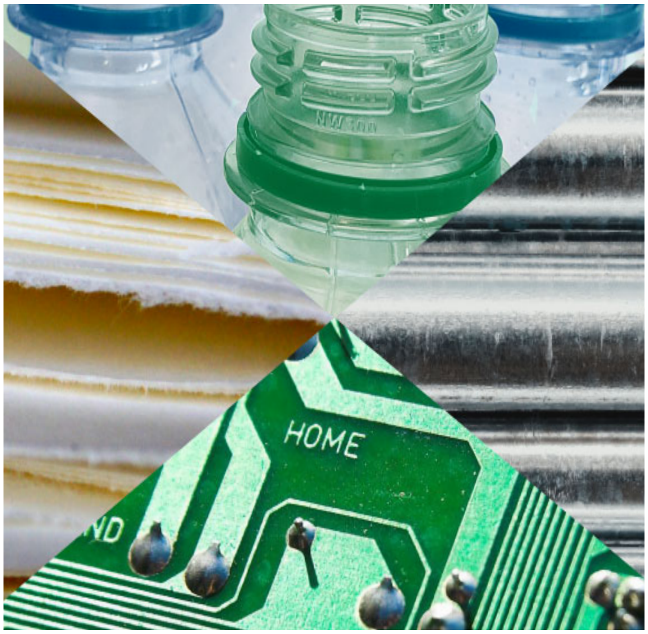
MAPPING RECYCLABLE MATERIALS FOR A CIRCULAR ECONOMY

Analysis provides a baseline for measuring progress in reusing metals, fibers (textiles and paper), polymers, and e-waste



Even for materials with relatively high recycling rates, such as aluminum, the U.S. and the world still have a long way to go in creating a circular economy. In a circular economy, products are designed with end-of-life in mind, and they yield valuable materials that are recovered for use in the next generation of products.

The REMADE Institute, named for the key benefits of reducing embodied energy and decreasing emissions, is working toward industrial processes that enable a circular economy. Measuring progress in this mission starts with fundamental knowledge about material flows and markets.

A project led by Yale University, together with the Institute of Scrap Recycling Industries, Unilever, Sunnking, and Massachusetts Institute of Technology, maps current and future pathways for recyclables in four primary categories: metals (carbon steel, stainless steel, aluminum), fibers (paper, textiles), polymers (PET, HDPE, LDPE/LLDPE, PVC, PP, PS, other plastic resins), and selected electronics (high-grade printed circuit boards found in desktop computers, laptops, smartphones, and tablets). The results provide baseline data to measure the technical performance metrics of projects and initiatives undertaken by REMADE.

PROJECT DESCRIPTION

The researchers analyzed U.S. material flows in 2017, REMADE's first year of operation. The characterized material cycles illustrate key processes within each supply chain, first-order estimates on the magnitude of the related flows, and recycling rates. The results can be used to prioritize research and evaluate the impact of ongoing and future projects.

In the past few decades, a variety of metrics have been used to report recycling data, which made it difficult to establish clear, consistent outcomes. The project's first step was to define a harmonized set of recycling metrics for metals, fibers, and polymers, allowing REMADE to conduct cross-material efficiency comparisons. The project focused on three metrics in particular: end-of-life recycling rate, recycled content, and old scrap ratio, which is the fraction of end-of-life material in secondary feedstock, as opposed to secondary material stemming from manufacturing inefficiencies. (The metrics covered e-scrap indirectly, since electronics consist of various materials including metals and polymers.)

Next, the researchers created up-to-date material flow analyses for fibers, polymers and selected metals and electronics at the U.S. and global levels. The material cycles quantified the amount of materials being processed and traded at all life stages and the shares in industrial end use sectors. The main life stages are primary production, fabrication (the process where materials are being produced, e.g. metal alloys), manufacturing (the assembly of final products), use (the end use of final products), and waste management including recycling.

The final task was to create supply and demand scenarios for the period 2017-2030. The researchers developed storylines and models incorporating population, per-capita wealth, and

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alternative technological transformations for four alternative pictures of the future that were based on the Shared Socioeconomic Pathways, a set of scenarios widely used in climate change and sustainability sciences: Sustainable Future, National Rivalries, Adaptation Challenges, and Fossil Fuel Everything.

An automotive case study complemented the overall picture of future supply and demand for these materials and provided insight into the transformation of initial forms of materials into the alloys, copolymers, and other sophisticated materials flowing into use (and ultimately from use into the recycling stream).

PROJECT IMPACT

This project achieved three goals. First, it collected baseline information on 2017 material flows, in the U.S. and globally, for four categories: metals, fibers, polymers, and e-waste. Second, the project demonstrated how to calculate the three most relevant recycling metrics for each material analyzed, and then it quantified these metrics for 2017. Finally, it provided supply and demand scenarios for the U.S. in 2030 that illustrate the potential share of secondary feedstocks in meeting estimated demand.

The baseline data developed in this project can be used to inform and prioritize research and evaluate the impact of ongoing and future projects.

NEXT STEPS

The researchers have conveyed this work through publications, a webinar, and poster sessions at the Annual REMADE Members Meetings and at the 2023 REMADE Circular Economy Technology Summit & Conference in Washington, D.C. The material flow analyses will serve as baselines for REMADE calculations on the impact of its projects, which target efficiency improvements in manufacturing and recycling processes, among other goals.

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PUBLICATIONS

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