Advanced Sorting Technologies for Food Waste

Technology Compilation & Innovative Solutions in Germany

Summary Series

IEA Bioenergy: Task 36: 01 2026

Author: Katrin Oldenburg & Leif-Alexander Garbe (Hochschule Neubrandenburg), Mona-Maria Narra, Satyanarayana Narra & Michael Nelles (Universität Rostock)

Edited by: Mar Edo (RISE), Michaël Becidan (SINTEF) & Anelia Milbrandt (NRL)

Advanced sorting technologies for food waste management play a crucial role in enhancing material recovery and reducing environmental impact within a circular economy framework. Globally, over 1.05 billion tons of food waste are generated annually, contributing between 8-10% of global greenhouse gas emissions with economic losses of approximately $1 trillion[1]. Germany produces approximately 10.9 million tons of food waste per year, representing 18.5% of the European Union's total, with households accounting for 59%. This accounts for 4% of Germany's national greenhouse gas emissions and results in annual economic losses of approximately 30 billion euros[2].

Despite Germany's established waste separation system, only around 63% of households have access to biowaste containers, and approximately 39% of residual household waste consists of biowaste that should have been separately collected. This mirrors broader European trends, where only 26% of food waste is effectively captured through separate collection systems, meaning that around 74% still ends up incinerated or landfilled[3]. Advanced sorting technologies can substantially improve organic waste stream quality by removing contaminants while recovering misplaced organic fractions from mixed waste streams. This creates dual environmental benefits: non-organic material is separated and recycled, while

---

[1] UNEP - United Nations Environment Programme (2024). Food Waste Index Report 2024. Think Eat Save: Tracking Progress to Halve Global Food Waste. https://wedocs.unep.org/20.500.11822/45230 (last accessed: 28.10.2025)

[2] NABU - Naturschutzbund Deutschland (2024) Zu viele Haushalte ohne Biotonne - Bioabfallsammlung kommt nicht vom Fleck. https://www.nabu.de/umwelt-und-ressourcen/abfall-und-recycling/bioabfall/biomuell.html?utm (last accessed: 05.12.2025)

[3] UBA - Umwelt Bundesamt (2021). Municipalities say thanks for separate collection of biowaste. https://www.umweltbundesamt.de/en/press/pressinformation/municipalities-say-thanks-for-separate-collection?utm (last accessed: 05.12.2025)

the organic fraction can be directed to valorization pathways such as composting or anaerobic digestion.

Food waste sorting technologies range from mechanical systems to artificial intelligence applications. Mechanical sorting systems employ shredders, vibrating screens, rotary drum sieves, and magnetic separators designed for organic waste streams containing plastic films, multilayer packaging, glass jars, and metal components. While economically favorable, these systems demonstrate lower efficiency in removing contaminants compared to advanced technologies, particularly struggling with lightweight plastics and complex multilayer packaging.

Optical and sensor-based systems utilize near-infrared spectroscopy to differentiate organic matter from polymers, combined with high-resolution visual recognition systems and laser scanners. By combining multiple sensors, they evaluate material composition, shape, size, and color simultaneously, providing very high accuracy in heterogeneous food waste streams. However, they require high initial investments and specialized maintenance, making them efficient for large industrial facilities but less accessible for smaller plants.

Artificial intelligence-based sorting systems offer unparalleled precision through deep learning and computer vision, detecting subtle differences in shape, texture, color, and material composition. Machine learning models self-improve over time through adaptive learning without requiring hardware replacement. Real-time image processing enables classification decisions within milliseconds, with accuracy rates commonly exceeding 90%, significantly reducing contamination in food waste streams.

Advanced detection technologies provide complementary capabilities. X-ray inspection systems enable density-based detection of contaminants like glass, metal, and bone fragments, even when embedded in packaged products. Hyperspectral imaging captures 100-250 narrow wavelength bands to produce spectral fingerprints revealing chemical composition, enabling high-precision sorting and early identification of spoiled food components. Metal detection systems employ multi-frequency scanning to identify contaminants as small as 0.3-0.5 millimeters, preventing entire product batches from being discarded.

System integration with Industry 4.0 principles has advanced significantly, with real-time processing systems achieving sorting accuracies of up to 99.9% with throughput capacities of several tons per hour. Modern systems incorporate artificial intelligence to classify complex irregularities, support predictive maintenance, and automatically log rejected products for batch-level traceability. Cloud-based platforms enable real-time remote monitoring, while AI-driven predictive analytics optimize process parameters autonomously.

ReFood, a company within Germany's Saria Group, provides an exemplary industrial-scale implementation. Operating 12 anaerobic digestion facilities across Europe, including 5 in Germany, supported by 14 logistics centers collecting waste from 60,000 points nationwide, ReFood processes up to 160,000 tonnes of food waste annually per facility. Their sophisticated mechanical separation systems employ counter-rotating screw augers, hammermill-based systems, and centrifuge-based separation technology. The Trossingen facility features two separate processing lines handling packaged and unpackaged waste streams independently, demonstrating a proactive response to German regulations.

ReFood's process achieves high-purity organic pulp with minimal contamination and clean separation of reject streams for recycling. After depackaging, waste is fed into anaerobic digesters, generating biogas upgraded to produce renewable electricity, heat, or biomethane, while digestate residue is used as organic biofertilizer. With nearly 100% material recovery rates and renewable energy production sufficient to power tens of thousands of homes annually, ReFood demonstrates significant CO_2 emissions savings by diverting food waste from landfill and displacing fossil fuels and chemical fertilizers.

Advanced sorting technologies enable the circular economy by integrating mechanical, optical, AI-based, and detection systems with digital infrastructures to achieve high recovery rates. With the European Union's mandatory food waste sorting policy in force since 2024, these technologies are essential for meeting Sustainable Development Goal 12.3 of halving per capita food waste by 2030. The German experience demonstrates that combining advanced sorting technologies with comprehensive collection systems and appropriate regulatory frameworks can transform food waste from an environmental burden into a valuable resource for renewable energy production and agricultural nutrient recovery.