Axis venture partners

The State of Circular Metals

How Europe is transforming waste into strategic raw materials

Christophe Pompee
Raj Mendhir
Upile Chasowa Beena
Tanna Akshay
Shende

Axis Venture Partners

May 2025

Circular Economy Acceleration: From Waste to Raw Wealth

Advanced recycling technologies are transforming end-of-life products into raw material sources, with the potential to meet up to 45% of Europe's critical mineral needs by 2040. Europe's green energy transition hinges on critical minerals – elements like lithium, cobalt, nickel, and rare earth that are essential for batteries, electric motors, and renewable energy equipment. However, Europe currently depends overwhelmingly on imports for these materials, a vulnerability as demand soars. To tackle this, industry and policymakers are accelerating a **circular economy** approach: turning end-of-life batteries and electronics into a strategic source of metals. Below we explore why critical minerals matter, how advanced recycling is reshaping material sourcing, the projected impact on Europe's supply by 2040, and the key projects and policies driving this shift.

Critical Minerals: Lifeblood of Clean Tech and Europe's Import Dependency

Critical minerals are the "**lifeblood**" of clean technologies – enabling high-performance batteries, wind turbines, solar panels, and electric vehicles. Europe's economy needs these metals, but it produces very few of them domestically. The EU relies on non-EU sources for most critical raw materials, leaving it exposed to supply risks. For example, **China provides 98% of the EU's rare earth elements** and dominates **59% of global lithium refining** and **73% of cobalt refining**. This import dependence is a strategic concern, especially as clean energy goals drive demand to new heights. A recent EU- sponsored study warned that by 2050 Europe will need **35 times more lithium** and **7 to 26 times more rare earth metals** than it consumes today.

Advanced Recycling Technologies: From End-of-Life to New Supply

In a circular economy model, end-of-life products (like used batteries and electronics) are **collected and processed** via advanced recycling, yielding secondary raw materials that feedback into manufacturing. Instead of discarding old lithium-ion batteries or electronics as waste, specialized facilities use mechanical and chemical processes to **extract metals** such as lithium, cobalt, nickel, copper, zinc, and rare earth elements. These recovered materials are then refined to high purity and fed back into the production of new batteries, magnets, stainless steel, copper products, and other alloys – reducing the need for virgin mining.

Europe currently generates around **5 million tonnes of e-waste** and collects **over 110,000 tonnes of used portable batteries** annually, with EV batteries expected to surge in volume in the coming years.

Nickel and Cobalt (from batteries and electronics): These metals are critical in producing stainless steel, nickel-based alloys, and superalloys. Recovered through hydrometallurgical and pyrometallurgical processes, they are refined to meet quality standards for high-performance applications. Current recycling technologies achieve **up to 95% recovery efficiency** for cobalt and nickel.

Copper (from electronics): Recycled copper is indistinguishable from newly mined copper and is widely used in electrical applications, copper alloys (like brass and bronze), and refined copper products. Europe consumes over **200,000 tonnes of nickel** and **50,000+ tonnes of cobalt** annually, much of it for clean energy technologies.

Zinc (from batteries and e-waste): Found in alkaline batteries and some electronics, recycled zinc is primarily used in **galvanized steel** production and in various **zinc alloys**. Hydrometallurgical recovery rates exceed **90%**.

Carbon Steel and Stainless Steel: While carbon steel is primarily iron-based, small amounts of nickel, cobalt, or copper recovered from e-waste can be included in speciality grades. Stainless steel, in particular, benefits from recycled nickel and chromium sourced from electronic waste. These recycled inputs help meet stringent alloy specifications.

The Recycling Process:

1. **Collection and Sorting:** E-waste and battery components are sorted by type.
2. **Shredding and Mechanical Separation:** The waste is mechanically broken down to separate valuable materials.
3. **Chemical Processing:** Techniques like acid leaching are used to extract nickel, cobalt, copper, zinc, and more.
4. **Refining:** Extracted metals are refined to meet specifications for reuse in alloy production.

Challenges:

- **Purity and Contaminants:** Rare metals extracted from electronics may be contaminated with **flame retardants, adhesives, lead, cadmium, and mixed plastics**, which complicate recycling and require advanced purification.
- **Complexity of E-Waste:** Devices often contain a variety of materials bonded together, including toxic or hard-to-separate components.
- **Economic Feasibility:** Recycling batteries cost about **$2.5–$3/kg**, or **$14/kWh** on average in Europe. Economic viability depends on market prices, recovery efficiency, and policy incentives.

Projected Impact: Up to 45% of Critical Mineral Demand Met by 2040

By 2040, advanced recycling technologies could supply up to **45% of Europe's demand for critical minerals**. This includes major inputs for batteries (lithium, cobalt, nickel), electronics (copper, rare earth), and speciality steels (nickel, chromium, cobalt). Certain metals, like cobalt and copper, may exceed 50% recycling-based supply shares, while others like lithium and rare earth will rise steadily as processing technologies scale.

This trajectory positions recycled metals not only as supplements to mining but as **primary sources** of raw materials across industries – from EV batteries to stainless steel production.

Axis venture partners

Economic Competitiveness and Scalability of Recycled Materials

Recycled battery raw materials such as cobalt, nickel, and lithium are not yet broadly cost-competitive with virgin mined metals. The costs of collecting and processing end-of-life batteries often exceed the value of the materials recovered. For example, recycling 1 kg of a nickel–manganese–cobalt (NMC811) battery cell can cost about €8.10, yet yields only around €4.20 worth of reclaimed metals. This gap forces recyclers to charge processing fees or seek subsidies to remain viable. However, as technology improves and operations scale up, the cost gap is beginning to close. Some large recyclers (e.g. Redwood Materials) report that their recycled metals are already produced at costs on par with mining new material, indicating that economies of scale and process efficiencies drive recycled materials toward competitive parity.

Key enablers for cost-effective scale-up include:

- **Process Innovation:** Developing more efficient recycling methods (e.g. direct cathode recycling or advanced hydrometallurgical processes) to boost metal recovery rates and reduce processing expenses. Higher recovery efficiency means more sellable material per unit of waste, improving profitability.
- **Economies of Scale:** Expanding recycling capacity and automation to achieve lower unit costs. Larger, high-throughput facilities can spread fixed costs over greater volumes, helping to eliminate today's cost disadvantage. Industry analysis suggests that with sufficient scale and improved recovery, recycling can turn from a cost centre into a net-positive value stream.
- **Collection and Logistics:** Strengthening collection systems and localised recycling infrastructure to secure a steady supply of end-of-life batteries while minimising transport and handling costs. Efficient reverse logistics and regional processing can significantly cut expenses (transportation is currently one of the largest cost components of battery recycling).
- **Policy Support:** Implementing supportive policies and market incentives to accelerate recycling. Measures like recycling subsidies, targets for recycled content in new products, and extended producer responsibility can improve the business case. For example, the EU's new Battery Regulation will mandate minimum recovery rates and recycled content for lithium, cobalt, nickel, and copper – steps that encourage investment in recycling capacity and help create a stable market for recycled materials.

This focused push on innovation, scale, efficient supply chains, and supportive policy is crucial for recycled raw materials to achieve full economic competitiveness and meet the growing demand sustainably. The combination of falling processing costs and proactive industry/government initiatives is expected to make recycled cobalt, nickel, lithium and other materials a much larger portion of the supply chain in the coming decades, improving both the cost-effectiveness and scalability of recycling.

EU Policy & Industry Support

The **EU Battery Regulation** (2023) mandates minimum recycled content in batteries and sets recovery efficiency targets (e.g., 90% for cobalt, nickel, and copper by 2027). The **Critical Raw Materials Act** further targets **15–25% recycled input** by 2030 for key minerals. These frameworks drive demand for recycled metals and support infrastructure development.

European companies like **Umicore**, **Northvolt**, and **Heraeus Remloy** are leading large-scale efforts to collect, refine, and reuse strategic metals from end-of-life products. Their initiatives demonstrate that **urban mining** can be both technically and economically viable.

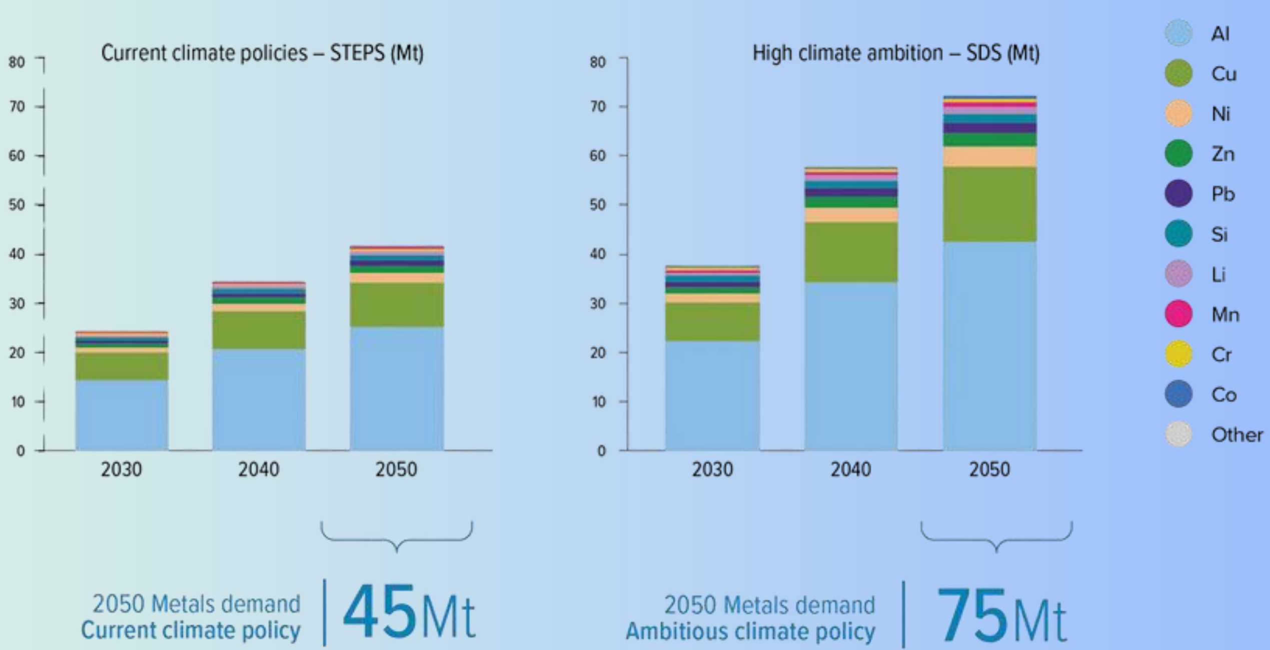
In addition to these industrial leaders, **young and innovative companies like Altilium (UK), Tozero (Germany), and Jiva Materials (UK)** are tackling the challenge of e-waste recycling. They are building **groundbreaking technologies** to improve recovery rates, lower the costs of battery and PCB recycling, and even enable **biodegradable electronic substrates**. Their contributions are critical to closing the loop and scaling Europe's circular economy.

Conclusion: Closing the Loop for Strategic Advantage

Recycling rare metals from batteries and electronics into high-quality alloys and primary metals is no longer just aspirational – it's actively reshaping Europe's material economy. With proper investment, regulation, and innovation, recycled sources can match or even surpass traditional mining in supplying key materials for energy, mobility, and infrastructure.

For Europe, embracing the circular economy is not just an environmental necessity – it's a strategic imperative for industrial sovereignty.

Global metal demand by commodity for clean energy technologies in a STEPS and SDS scenario respectively (Mt*)



Source: Eurometau/, Metals for Clean Energy: Pathways to solving Europe's raw materials challenge (2022)

About Axis Venture Partners:

Axis Venture Partners, a UK-based firm specialising in corporate innovation, venture capital as a service and Fractional C-Suite services. Our approach focuses on helping corporations achieve their strategic goals through venture capital investments while enabling scale-up companies to unlock their growth potential.