

Chasing the lost copper: Global scrap and its role in decarbonization

Increasing circularity in copper could significantly lower emissions—but first, the industry will need to capture uncollected copper scrap.

This article is a collaborative effort by Peter Spiller, Sebastian Göke, and Sergey Sokolov, with Daniel Keogh and Diedrik Tas, representing views from McKinsey's Energy & Materials Practice.



Executive summary

Across the copper value chain, companies are setting ambitious targets to reach carbon neutrality in the next decade. This push for decarbonization coincides with increasing demand for copper—driven by the metal’s significance in future-facing applications such as batteries, renewable energy, and electricity transmission and distribution—as well as restricted supply. In fact, the world is expected to face a refined-copper shortfall of about 3.6 million metric tons (Mt) by 2035, according to McKinsey analysis.

Copper recycling could be the key to solving the supply challenge. Increasing the capture of secondary copper (that is, postconsumer copper scrap such as e-waste) would open new supply sources and eliminate emissions from producing primary copper. This should go hand in hand with a further build-out of secondary-copper smelting capacity. It could also enable a more secure copper supply in the future. All in all, developing circular value chains for copper will take a strong push from producers to secure and increase secondary-copper volumes and a strong pull from OEMs and end consumers who value recycling and decarbonization.

This article is part of a series on increasing the circularity of materials. To access the growing (and partly uncollected)

scrap pool, copper producers should consider partnerships and investments in the copper scrap collection and processing value chain. As these secondary-copper value chains develop, there will likely be greater competition to secure postconsumer scrap volumes, making it critical to be more proactive.

Challenges to increase copper scrap volumes

The copper value chain relies on two types of inputs: copper ore from mines (that is, primary copper) and scrap. Preconsumer scrap is recovered from the manufacturing process, and postconsumer scrap is recovered from products at end of life. Both ore and scrap can be refined to make copper that is usable in other products. Because refined copper is a commodity, it is less differentiated than the wide variety of plastics, glass types, or even steel types. Recycling copper scrap is thus in some ways simpler than recycling other materials. However, companies looking to introduce new circular supply and decarbonize refined copper supply chains face three main challenges:

1. *Limited scrap supply.* Approximately 60 percent of postconsumer copper scrap will enter the formal recycling value chain globally in 2035; the remainder is

either lost, collected informally, or uncollected (for example, if it is possible to recover but difficult to access). Accounting for processing losses, the share of formally recycled and reused copper units further reduces to about 45 percent of the total copper content of postconsumer scrap.

2. *Mixed end products.* Copper is often only a partial component in a given end product, meaning it needs to be extracted or separated from anything that has been recycled. Impurities in collected copper mean that scrap volumes may need to be re-refined or downcycled.
3. *Sourcing.* It is difficult to track the provenance of copper scrap across geographies and end sectors.

These challenges vary by region but generally hold true across the global copper industry. The first step in improving circularity and reducing mine-based emissions is to raise awareness of the full copper value chain so that stakeholders can take informed action.

Global demand for copper is expected to exceed supply by 2035, increasing the need for scrap

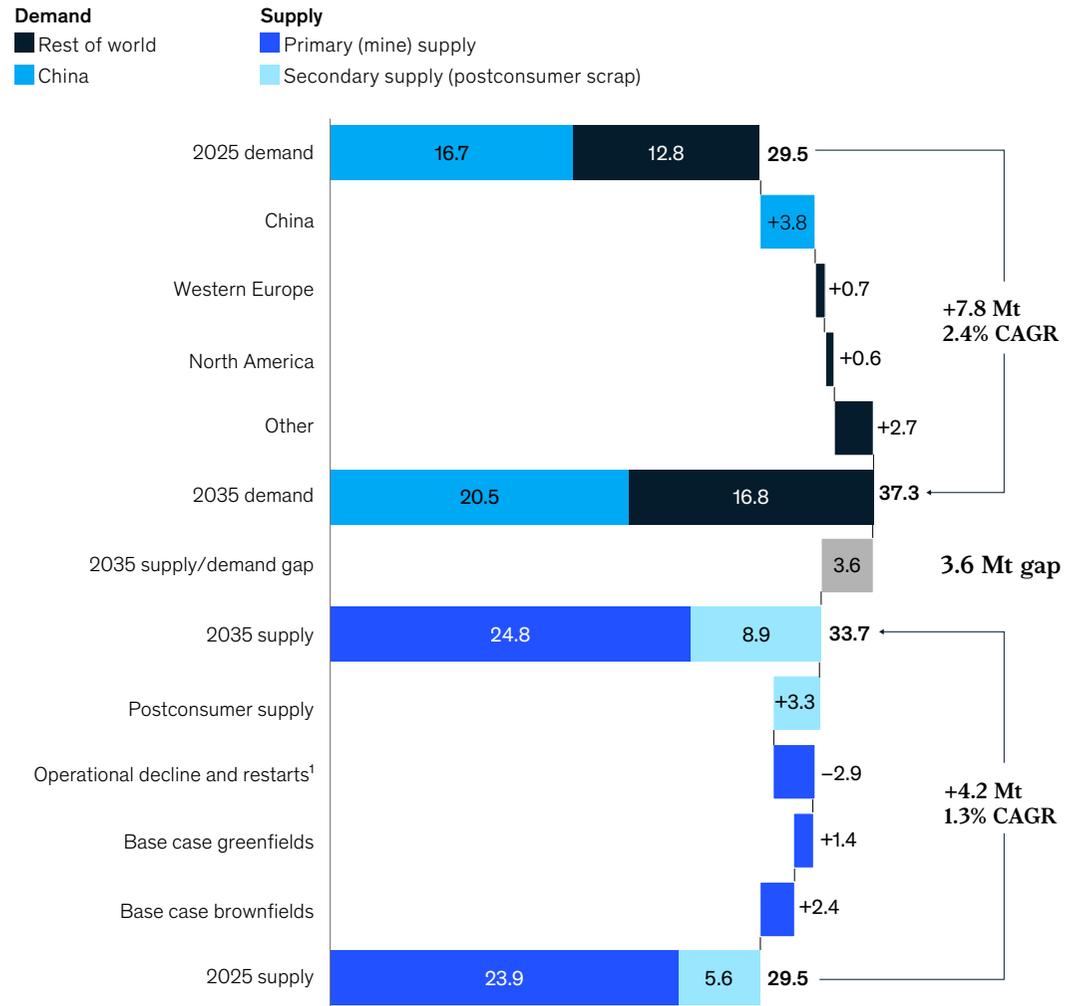
Because of a sharp increase in copper demand and a slowdown in primary supply growth, we expect the supply of refined copper to fall about 3.6 Mt short of estimated demand through 2035.

From 2025 to 2035, global demand for refined copper is expected to grow from 29.5 Mt to 37.3 Mt, a rate of about 2.4 percent per annum. This growth will be propelled by an expansion of transportation and electrical infrastructure in critical markets, including China, Western Europe, and North America.

Higher copper prices may encourage mines to further increase supply, which could reduce the emerging deficit. The supply of copper from mines is expected to increase from 23.9 Mt in 2025 to 24.8 Mt in 2035 as new mines ramp up production, counteracting operational declines and closures. We expect further development in existing mining sites to represent two-thirds of these new additions. In addition, the amount of collected and recovered copper postconsumer scrap is expected to increase from 5.6 Mt to 8.9 Mt by 2035 (mainly propelled by growth in postconsumer scrap generation). However, this increase will not be able to fully make up for the supply deficit in our base-case scenario and will require a further build-out of secondary-smelting capacity to use all available postconsumer copper scrap generated. In fact, current projections of scrap processing capacities for 2035 suggest a processing gap of more than one million metric tons.

Rising copper demand and a slowdown in primary-supply additions could create a supply gap of more than 3.6 million metric tons by 2035.

Copper supply and refined copper demand, 2025–35, million metric tons (Mt) refined copper



Note: Base case scenario. Figures may not sum, because of rounding.
¹Net effect of operational improvements, new mine ramp-ups, restarts, closures, and operational decline.
 Source: McKinsey MineSpans

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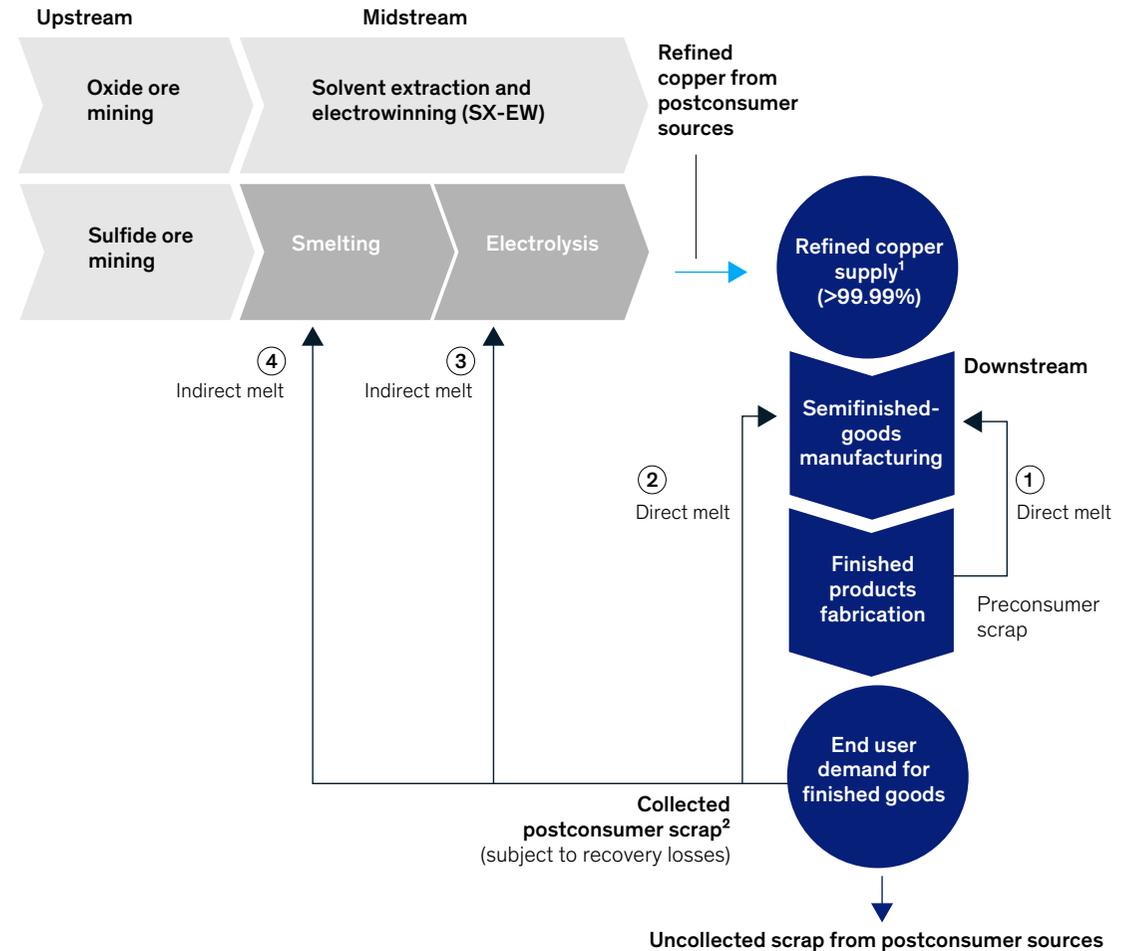
Optimizing the copper recycling value chain would bolster supply

In the context of a supply deficit for copper, scrap can be used as an alternative, low-carbon feedstock to produce refined copper in four ways:

1. *Direct melt of preconsumer scrap.* Scrap from manufacturing processes has a known composition and few impurities. Therefore, it can be directly reused, with no re-refinement required.
2. *Direct melt of postconsumer scrap.* The highest-purity, uncontaminated postconsumer scrap (such as busbars) can be directly processed into semifinished copper products such as wires and tubes.
3. *Indirect melt of higher-quality postconsumer scrap.* Higher-quality scrap from products that have reached the end of their life cycles can be re-refined to raise the purity levels of refined copper.
4. *Indirect melt of lower-quality postconsumer scrap.* Nonalloyed postconsumer scrap of lower quality requires resmelting to remove impurities. This scrap is also used to regulate smelter temperature.

Scrap can be recovered throughout the value chain from the manufacturing process or from products at the end of life.

Overview of the copper value chain



¹Split in share from mining and share from postconsumer scrap.

²Collected scrap is scrap entering the recycling value chain at the end of the estimated product lifetime (eg, collected by scrap collectors and further processed). Source: McKinsey MineSpans

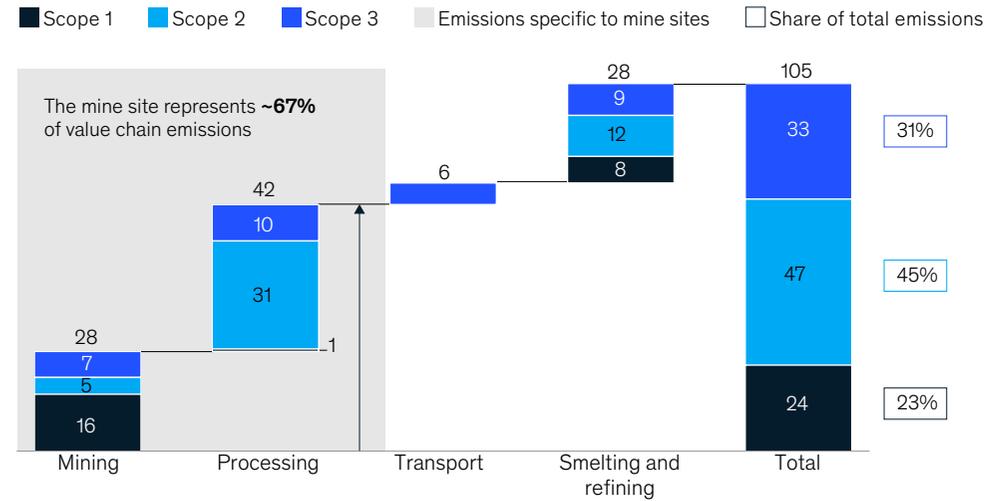
As a low-carbon feedstock, copper scrap is a key catalyst for decarbonization

Because scrap has already been mined and processed, using it instead of primary copper can reduce a final product's carbon intensity. About two-thirds of CO₂ emissions in the copper value chain are concentrated at the mine site, where minerals are mined and processed. Mining activities account for about 27 percent of total value chain emissions, and mineral processing accounts for about 40 percent. More than half (about 51 percent) of emissions specific to mine sites are attributed to purchased electricity (Scope 2 emissions). Together, smelting and refining copper make up more than one-quarter of total value chain emissions (about 27 percent), and transportation accounts for the remaining 6 percent.

The global average CO₂ intensity for refined copper from secondary-only material is 0.6 metric tons of CO₂ per metric ton (tCO₂ per t), compared with between 2.9 and 3.7 tCO₂ per t for refined copper derived predominantly from ores. As a result, circularity through the increased use of secondary copper (especially as direct melt) represents one of the largest and easiest methods to achieve decarbonization.

Cathodes with 100 percent recycled content emit about 85 percent less carbon than cathodes derived predominantly from concentrates.

Baseline copper value chain emissions,¹ 2030, million metric tons of CO₂ (MtCO₂)



Cathode-level emissions by source,² tCO₂ per metric ton of cathode



Note: Figures may not sum, because of rounding.

¹Value chain for copper cathode product; emission figures assume a balanced market in 2030.

²Global production-weighted average intensity, CO₂ emissions only.

Source: McKinsey MineSpans

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Postconsumer copper scrap use is expected to grow approximately 4 percent per annum through 2050

The volume of postconsumer copper scrap has risen steadily over the past four decades. It is expected to continue to grow by about 4 percent per annum from 2020 to 2050, reaching a total of approximately 14 Mt by 2050.

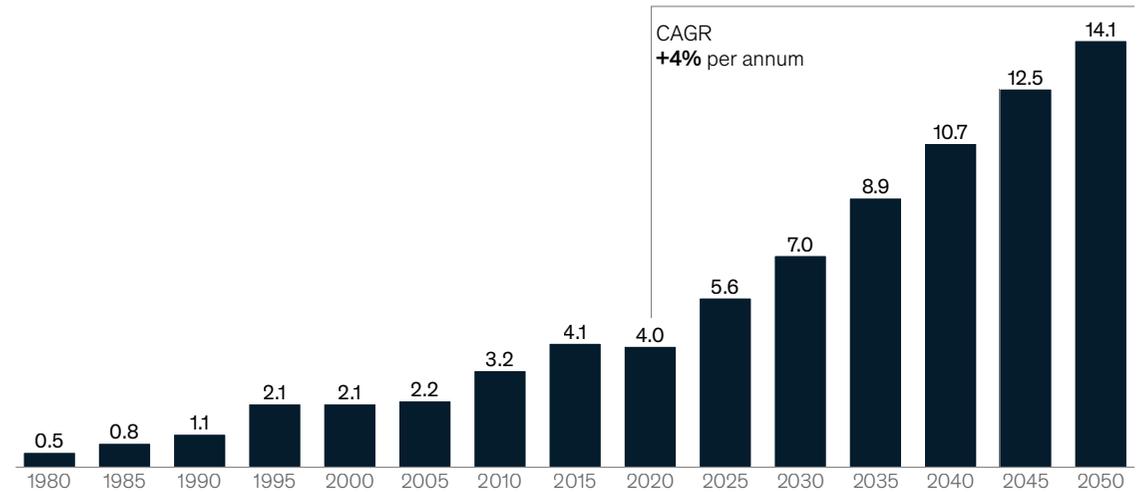
The increased use of scrap is driven by several factors:

- As more copper is consumed, the availability of scrap increases.
- More consumers and governments have promoted a circular economy, which has increased collection rates of scrap.
- There has been an increased awareness of the carbon emissions produced by primary pyrometallurgy and an effort to lower the overall CO₂ footprint per t of refined metal.

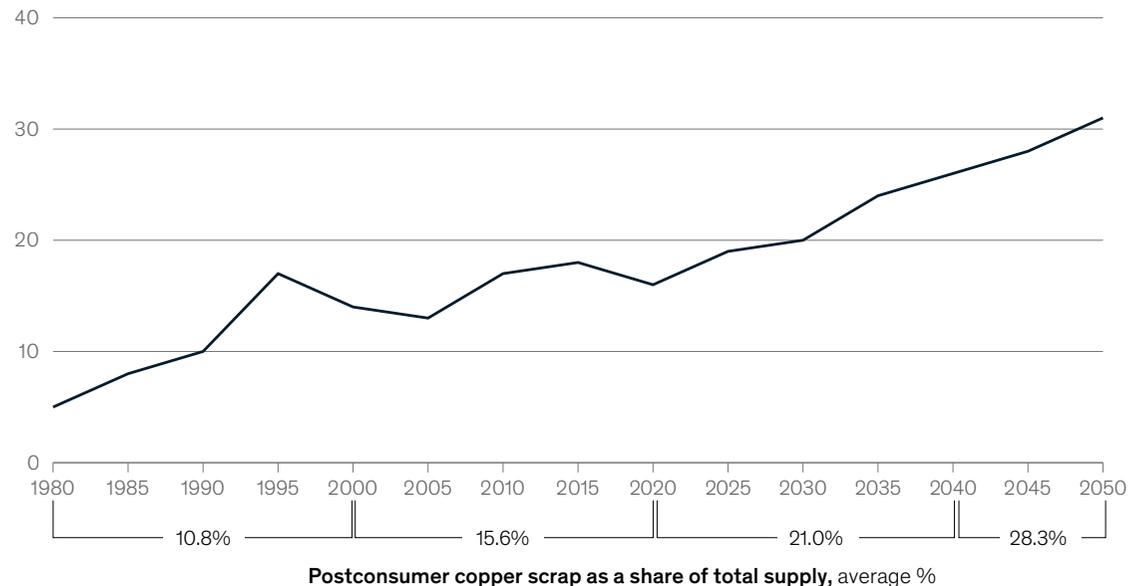
Currently, the average postconsumer content of refined copper supply is about 20 percent, whereas the copper scrap used in refined-copper production represents about 45 percent of the estimated copper volumes contained in all products that currently reach end of life.

Postconsumer scrap is expected to grow to about 25 percent of the overall copper supply by 2035.

Postconsumer copper scrap supply, million metric tons (Mt)



Postconsumer copper scrap supply as a share of total copper supply, %



Source: McKinsey MineSpans

The uncollected-scrap pool provides a key pathway to increase circular copper volumes

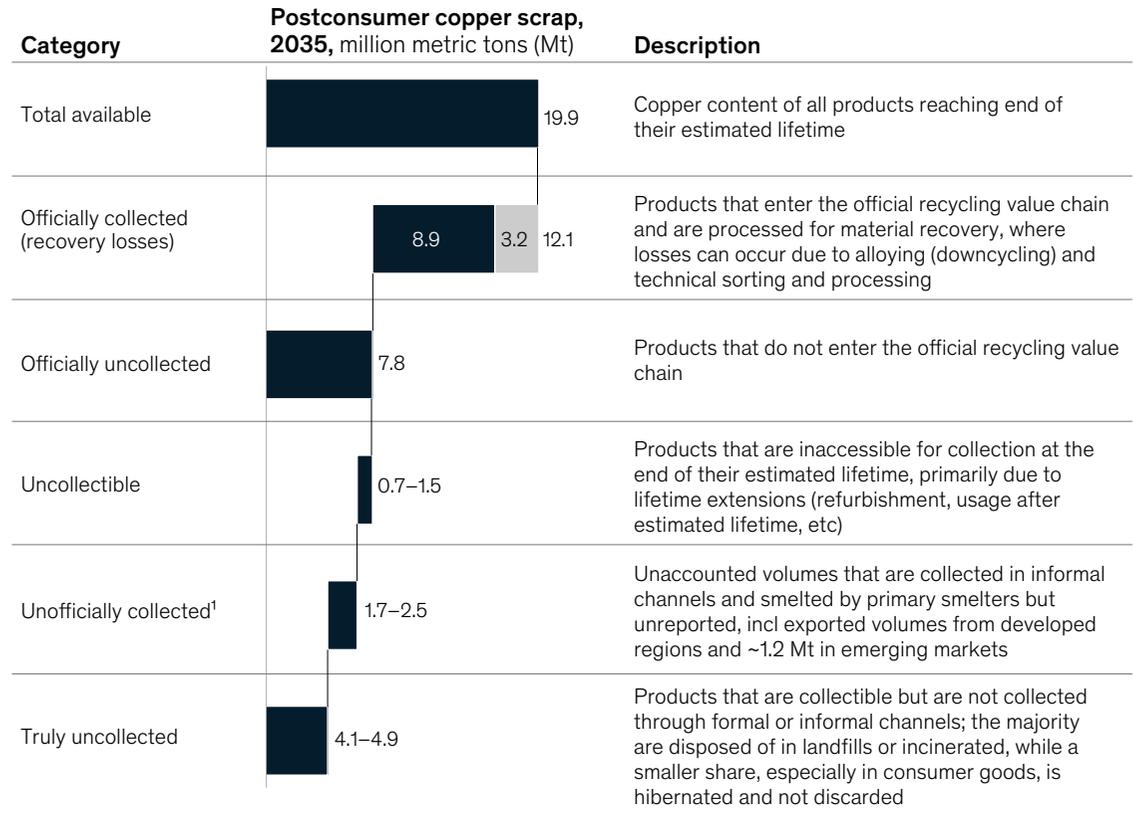
Although postconsumer scrap volumes are growing, about 40 percent (7.8 Mt) of the anticipated total scrap pool is not expected to enter the official recycling value chain by 2035.

Scrap can be uncollected because of longer-than-expected product lifetimes. For example, vehicles have an estimated lifetime of 17 years but can last longer than that. In addition, it is often uneconomical to collect scrap before it enters landfills because of labor costs. Furthermore, in developing markets, a large portion of scrap does not enter the formal recycling ecosystem. Copper from these sources is not accessible to global companies that require quality control and traceability.

The majority of products that are not collected through either formal or informal channels are disposed in landfills or incinerated. A smaller share, especially in consumer goods, is hibernated and not disposed.

By addressing uncollected postconsumer scrap, producers could recover up to four to five Mt of additional copper supply by 2035.

By 2035, we expect that nearly eight million metric tons of scrap will remain out of the official recycling value chain annually.



¹Unofficially collected volumes represent estimation based on expert talks; volumes are not recorded.
Source: European Commission; McKinsey MineSpans; McKinsey analysis

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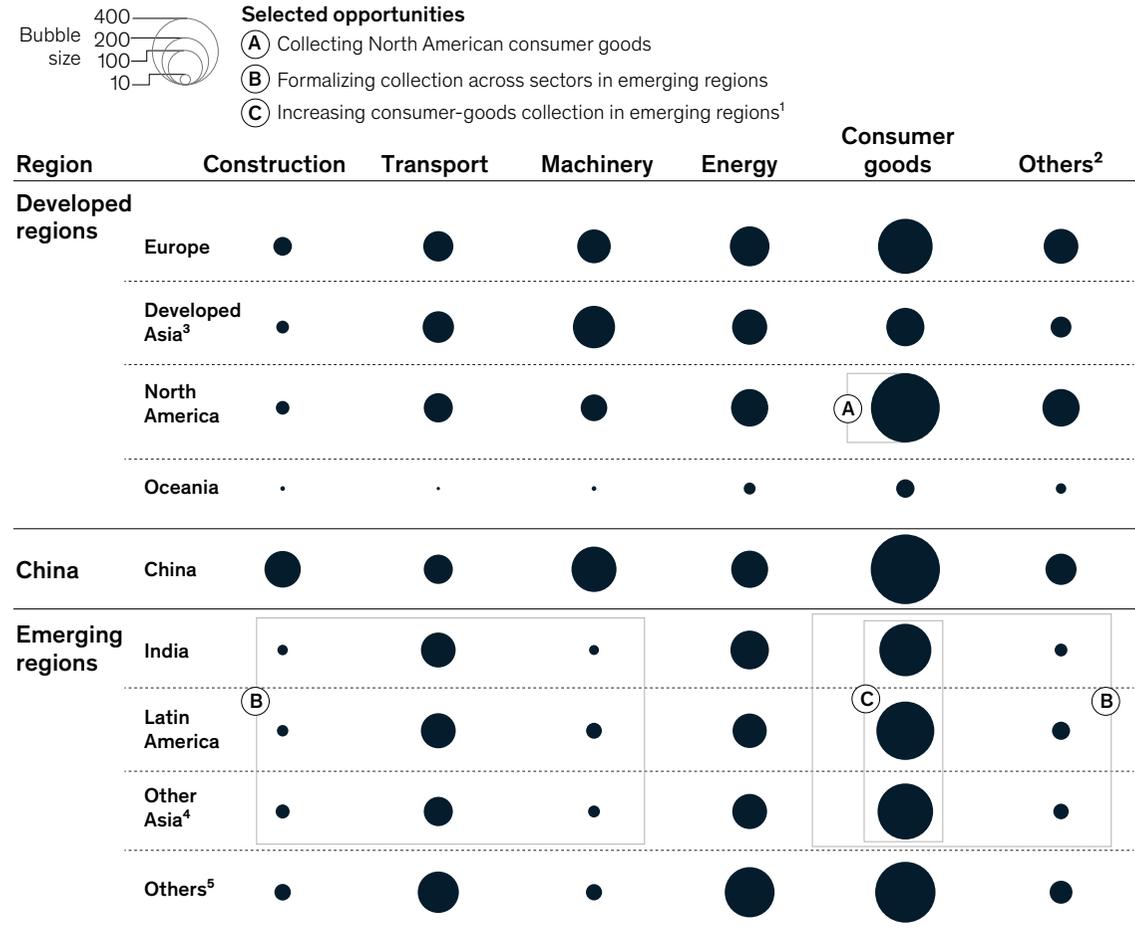
Three opportunities to tap into uncollected copper scrap stand out

Untapped value pools of postconsumer copper scrap can be found across regions and sectors. Of the pools available, three are particularly promising:

- Consumer goods in North America.** Large volumes of e-waste and low-grade material in consumer goods are not collected and end up in landfills. To increase the treatment of e-waste, stakeholders need to establish and expand recycling systems to improve recovery of e-waste and divert low-grade material from landfills. Public awareness campaigns could support collection efforts, as could creating waste collection or return programs through partnerships between consumer goods companies and upstream companies. Collection could also be supported by introducing systems for extended producer responsibility (EPR) and stronger e-waste regulation in critical US states. In addition, the absence of economic incentives to recycle low-grade e-waste and secondary-smelting infrastructure discourage collection. Regulatory incentives or higher copper prices may be required for at-scale, downstream secondary-smelting capacities to grow and to improve the business case for lower-grade e-waste recycling in future.
- Formalization of collection across sectors in emerging regions such as India, Latin America, or Other Asia.**¹ In emerging regions, global companies lack access to a large system of informal scrap collection channels. By formalizing collection processes with regulatory support and the development of collection infrastructure, global organizations could begin to gain access to these pools. For example, regulations aimed at increasing recognition, registration, and tracking of formal scrap collection activities, paired with incentives for employment in formal (rather than informal) collection, could stimulate

Postconsumer scrap volumes vary across regions and industries, with a few key areas standing out.

Addressable uncollected postconsumer scrap (before recovery), 2035, metric kilotons



¹This category includes only consumer goods in emerging regions.

²Eg, clothing (buttons), ammunition, and coins.

³Incl Japan and South Korea.

⁴Incl Indonesia, Thailand, and Vietnam.

⁵Incl Commonwealth of Independent States, Middle East and North Africa, and sub-Saharan Africa.

Source: McKinsey MineSpans

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¹ "Other Asia" includes Indonesia, Thailand, and Vietnam.

the formalization of collection streams. Partnerships (for example, between nongovernmental organizations and multinational corporations) could accelerate the joint buildup of needed formal infrastructure, such as training and equipment.

3. *Improved consumer goods collection in emerging regions.* As in the United States, copper in emerging regions (India, Latin America, and Other Asia, for example) often ends up in landfills in the form of e-waste and consumer goods. Likewise, increasing recycling awareness and introducing systematic recycling channels could help improve scrap collection. These measures could include the introduction of EPR schemes, regulatory enforcement of e-waste recycling, and subsidies for formal streams. For example, e-waste regulations in India have successfully improved collection rates. As other regions have done, emerging regions could introduce return programs to facilitate the disposal of consumer electronics and household appliances or consider regulatory incentives for the build-out of collection infrastructure such as collection points and downstream smelting.

In addition to these three areas, companies can look into increasing their existing share of collected scrap supply, although this area has already largely been explored.

Increasing recycling awareness and introducing systematic recycling channels could help improve scrap collection.

Midstream and downstream copper companies are discovering new pools of copper scrap through circularity

Stakeholders around the world are making a strong and increasing push toward circular products. To meet their needs, companies across the copper value chain are building circularity capabilities in three key ways:

- Mitigating supply risk through procurement.** Players are cooperating across the value chain to secure secondary feedstock through long-term supply contracts, partnerships, and “closed loop,” or circular, agreements. They are also securing their supply by investigating uncollected scrap pools that are not entering the official recycling value chain.
- Meeting decarbonization targets through innovation.** Copper companies are looking into technology that can help them capture more value from scrap. Some companies are building technology through proprietary R&D, and others are partnering with companies in the industry to increase the ratio of copper scrap intake in smelters (for example, through hybrid smelting), the efficiency of intermediate scrap product processing, and the metal recovery rate of lower-grade postconsumer scrap. Companies are also building circular business models to decrease the need for raw materials within the value chain. For example, smelters are testing the use of hydrogen in the production process.
- Achieving circularity objectives through investment and M&A.** Companies are making capital expenditure investments to increase scrap processing capacity and lower emissions. For example, many copper refiners are switching to renewable energy. Companies are also making M&A investments in critical secondary-materials organizations, focusing on organic or inorganic growth to enlarge recycling capacity, increase existing secondary smelting or build new secondary smelters from scratch, and increase the value chain footprint through vertical integration.

Companies in the copper value chain are reducing emissions by focusing on procurement, innovation, and investment.

✓ Companies involved or affected

Key areas	Archetypes of potential actions and levers	Scrap recyclers	Copper producers	OEMs	Other ¹
(A) Procurement	1. Establishing long-term contracts between downstream players to secure the supply of recycled semifinished products or between scrap copper traders and copper producers to secure copper scrap	✓	✓	✓	✓
	2. Creating closed-loop agreements between OEMs and mid- and downstream players to ensure consistent flow of postconsumer material	✓	✓	✓	
	3. Investigating uncollected scrap pools not entering the official recycling value chain	✓	✓		✓
	4. Valorizing the residual fraction in the tailings through upcycling or downcycling	✓			
(B) Innovation	1. Increasing the ratio of copper scrap intake in smelters		✓		
	2. Increasing the efficiency of intermediate product processing for reuse and the extraction of precious metals for resale	✓	✓		
	3. Increasing the metal recovery rate of postconsumer scrap categories to enable a higher conversion into pure copper products and resale of other valuable metals	✓	✓		
(C) Investment	1. Enlarging recycling capacity through capital expenditure investment or through vertical integration with metal recyclers	✓	✓		
	2. Increasing existing secondary smelting capacity or building new capacity in strategic locations		✓		
	3. Engaging in M&A activity with downstream players such as vertical integration to increase value chain footprint	✓	✓	✓	✓

¹Eg, financial investors, policymakers, associations, and traders.

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Conclusion

Several companies across the copper value chain in Asia, Europe, and North America are already actively investing in expanding their secondary-copper smelting capacity—a crucial prerequisite for utilizing all available postconsumer copper scrap. Additionally, they are forging direct relationships to enhance their access to scrap. Different types of procurement agreements have already begun to emerge. Secondary players such as battery and copper foil manufacturers have signed long-term contracts with materials producers to secure copper scrap

supply. Companies have also established closed-loop agreements with manufacturers to ensure consistent flow of postconsumer materials. For example, automotive manufacturers and battery materials manufacturers have partnered to form closed-loop supply chains, for electric-vehicle batteries from raw materials to recycling. Finally, players have begun creating circular market ecosystems with producers to provide transparency and traceability on materials sourcing.

Establishing these ecosystems could increase the collection and recovery of copper scrap volumes, allowing companies—and the planet—to reduce waste and make the most of what's already out there. Being at the forefront of creating these circular supply chains could allow players to get advantageous access to scrap pools and reduce the expected future copper supply gap. In the hunt for this lost copper, acting soon and strategically will be key.

Peter Spiller is a partner in McKinsey's Frankfurt office, **Sebastian Göke** is a partner in the Berlin office, **Sergey Sokolov** is a partner in the Almaty office, **Daniel Keogh** is a consultant in the London office, and **Diedrik Tas** is a senior expert in the Brussels office.

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