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Recycled Copper: Smelting or Melting?

The nuances of secondary copper smelter emissions

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In this focus piece, we explore smelting or melting and the nuances of secondary copper smelter emissions. Copper is indispensable for the clean energy transition. It conducts electricity better than almost any other metal and is used in wind turbines, electric vehicles and smart grids. According to the [ICSG](#), secondary copper accounted for 17% of global refined production in 2024. As demand for copper rises, investors and policymakers are asking where the material comes from and what its carbon footprint looks like.

Many assume that recycling copper scrap is always cleaner than smelting mineral concentrate. Our combined experience in smelting operations, process technology and greenhouse-gas accounting tells a more nuanced story. This article presents our analysis of greenhouse-gas (GHG) intensity across the global smelting universe, highlighting why some secondary smelters achieve very low emissions while others do not.

Before we go further, it is important to clarify what we mean by melting and smelting and why we treat them separately. A secondary smelter receives scrap or low-grade metal and undertakes the full metallurgical sequence: melting in a furnace, reacting and separating slag, converting to remove impurities, and finally refining electrochemically. A remelter, by contrast, melts already-refined cathode copper and high-grade copper scrap and casts it directly into semi-finished products such as rods or bars.

Industry statistics sometimes group both categories together because they both involve heating metal. Yet the metallurgical complexity, energy demand and resulting carbon emissions are fundamentally different. Remelters do not form slag, blow off impurities or operate converters; they simply re-liquefy cathodes and high-grade copper scrap. This minimal processing translates into very low GHG intensity.



Challenging the narrative: Carbon Footprint of Secondary Copper

Our analysis shows that secondary smelting is **not automatically low carbon**.

The carbon footprint of a smelter is shaped by:

- Technology
- Energy mix
- Quality & origin of feed



This analysis is a collaboration between [Dr. John Anderson](#) and [Fernando Araya Burchard](#).

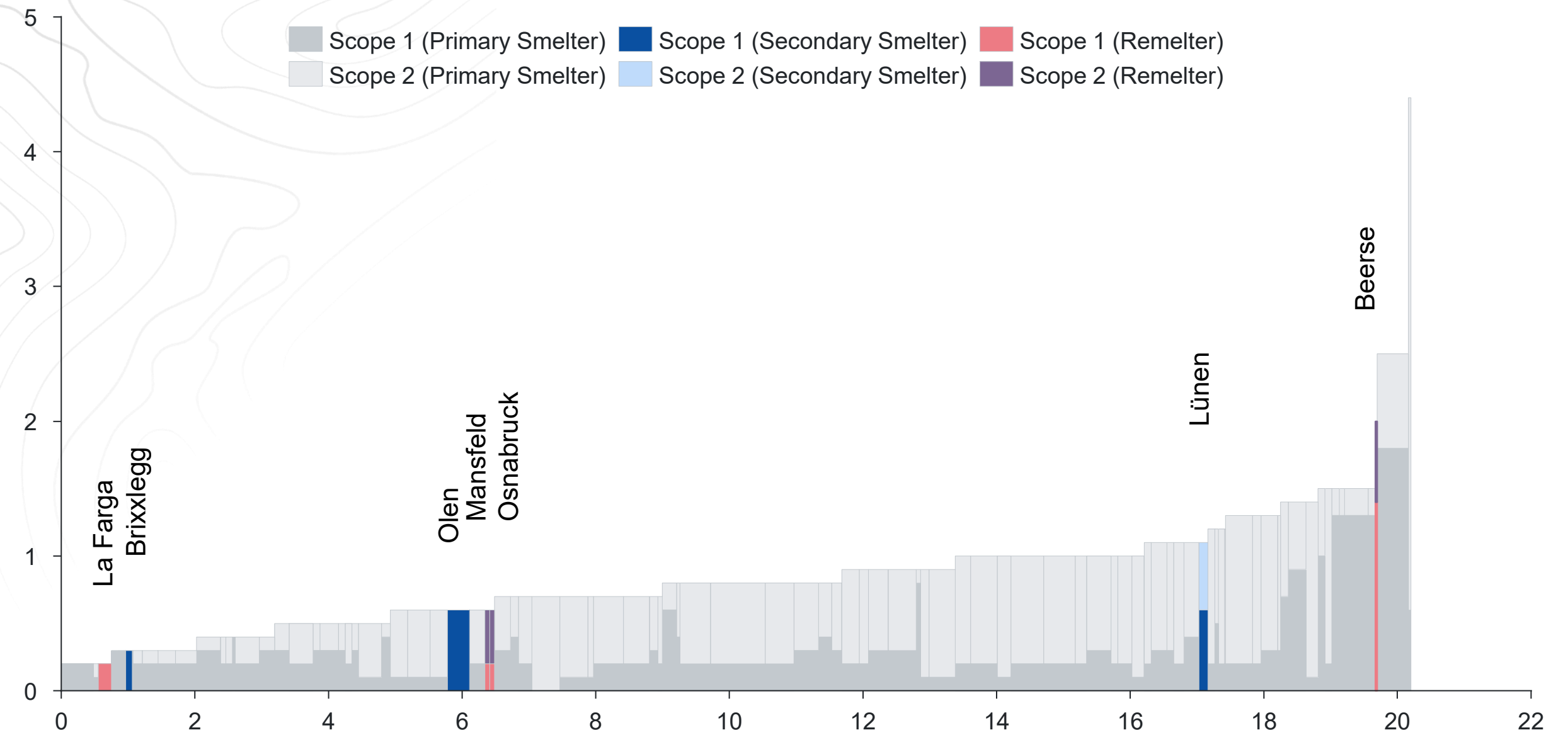
To visualise the landscape, we have built a primary and secondary smelter GHG intensity curve. The majority of the assets on the curve are primary smelters. Their intensities range from 0.2 to 4.4 t CO₂e per tonne of copper because modern pyrometallurgical processes rely heavily on natural gas or coke and draw electricity from grids that are often fossil intensive. We have also highlighted a select group of secondary smelters and remelters.

The curve shows that **secondary smelters do not cluster together**. Montanwerke (Brixlegg) produces about one hundred thousand tonnes of cathode copper per year. Its GHG intensity is roughly 0.4t CO₂e per tonne. Brixlegg achieves this low value because it draws most of its power from three on-site hydroelectric plants and a rooftop photovoltaic array; it sources the remainder from local hydropower. The plant still burns some natural gas and coke in its shaft furnace, but the renewable electricity supply keeps its Scope 2 emissions minimal.

Lünen (Aurubis) processes about ninety thousand tonnes of scrap. Its intensity is closer to 1.2 t CO₂e per tonne. The site uses a bath smelting reactor and relies on the German grid, which remains coal heavy. There is no public evidence of a renewable power purchase agreement for Lünen, so the facility's Scope 2 emissions are high. Its fuel consumption resembles that of a primary smelter because it treats complex scrap streams that require high temperatures and oxygen.

Beerse (Aurubis) treats roughly 50kt/year of complex scrap. Its intensity is around 2 t CO₂e per tonne because the plant uses a top-blown rotary converter and likely consumes large amounts of natural gas and coke. The Belgian grid has lower carbon intensity than the German grid but is still not low enough to offset the high fuel use.

Carbon emission intensity: Primary¹ vs. Secondary^{1,2} copper production (tCO₂e / tCu)



Source: ¹ Skarn Associates, ² Fernando Araya Burchard

Olen (Aurubis), also in Belgium, purchases renewable electricity through a long-term offshore wind contract with Eneco. That agreement cuts its Scope 2 emissions, and we estimate its total intensity at about 0.6 t CO₂e per tonne.

We also include three remelters: La Farga, Mansfeld and Osnabrück. These facilities melt already-refined cathodes to produce wire rod and other semi-finished products. They use electric or gas-fired holding furnaces and consume around 0.3 MWh per tonne, giving them total intensities well below 0.2 t CO₂e per tonne. Remelters are not part of the scrap-to-cathode supply chain because copper cathodes form a very significant part of their feed, but they illustrate how different technologies map onto carbon outcomes.

Technology and energy use

Smelter technology is the first driver of GHG intensity. Primary smelters melt sulphide concentrates in flash furnaces or other bath reactors. They then convert the molten matte to blister copper, refine it in an anode furnace, and finally electro-refine it in a tankhouse. Each stage demands heat and oxygen, which come primarily from fossil fuels and electricity. Even high-efficiency flash smelters consume about 10GJ per tonne of anode copper (around 2.8MWh) before electro-refining adds another 340kWh.

Secondary smelters start with copper contained in scrap or black copper. The best performers, such as Brixlegg, use a shaft furnace where the oils and plastics on scrap contribute heat. Natural gas, coke and oxygen make up the difference. Smelters like Lünen and Beerse operate bath smelting reactors similar to those used for concentrates. The scrap feed is more diverse and can include printed circuit boards and other materials with low metal content and significant plastic. These materials require more energy to process and produce off-gases that need treatment.

Remelters melt cathodes in induction furnaces or small gas-fired furnaces and cast them into products such as wire rod. Because the feed is already refined, there is no need for converting or slag treatment. Energy use is dominated by electricity, and total consumption can be as low as 0.3MWh per tonne.

Location and electricity mix

Electricity accounts for about a third of the energy used in copper smelting. Its carbon intensity depends entirely on where it is sourced. For example, Skarn's research shows that Austria's grid is largely hydro based and has a carbon factor of roughly 0.02 kg CO₂e per kWh. Germany's grid still relies heavily on coal and lignite and has a factor of around 0.35 kg CO₂e per kWh. Belgium lies between the two at about 0.13 kg CO₂e per kWh, but companies can change their effective emission factor by signing renewable power purchase agreements. Aurubis's Olen plant purchases offshore wind power. By contrast, plants without such agreements are exposed to the full carbon intensity of their national grid. Plants in regions with abundant hydro or nuclear power can cut their Scope 2 emissions significantly, whereas those drawing from coal-heavy grids struggle to do so.

If you'd like to see our coverage of secondary copper smelters extended, please send us an [email](#).

Raw materials quality, volume and logistics

The third determinant of carbon intensity is the availability and quality of feed. Secondary smelters rely on scrap: some of it consists of bus bar offcuts or bare cable with more than 90 per cent copper, while other streams include electronic waste with less than 20 per cent copper and high plastic content. Processing low-grade scrap requires more energy per tonne of copper and produces more slag and off-gas. Plants like Brixlegg, which work with high-purity scrap and black copper from other refineries, achieve higher recovery and lower energy use. Lünen and Beerse handle more complex materials, including printed circuit boards and refinery residues, which increases their energy requirements.

Scrap availability is also shaped by global trade. China imports large volumes of scrap to supply its own recycling industry. European smelters must compete for the same material, sometimes shipping it across continents. Transporting one tonne of scrap from Europe to Asia emits roughly 0.1 t CO₂e. These transport emissions can erode the benefits of recycling. Securing local feed therefore benefits both cost and carbon performance. Some secondary smelters also blend in anodes from other facilities; Brixlegg, for example, supplements its scrap with anodes from Kovohuty. This practice boosts throughput but mixes primary and secondary sources, complicating claims of "100 per cent recycled copper."

A further argument often cited in favour of secondary copper is its inherently lower upstream emissions, since scrap avoids the carbon-intensive stages of mining, beneficiation, and concentrate transport. In principle, this advantage is real and material. However, it is frequently overstated in isolation. Once scrap is mobilised across long distances, processed to remove contaminants, or competed for in global markets, a portion of that upstream advantage is eroded. The net carbon outcome therefore depends not only on whether the feed is scrap or ore, but on how far it travels, how it is prepared, and how efficiently it can be integrated into the metallurgical flowsheet.

A nuanced story

Our analysis shows that secondary smelting is not automatically low carbon. The carbon footprint of a smelter is shaped by the technology it uses, the emissions associated with its electricity and fuel, and the quality and origin of its feed. A secondary smelter powered by a fossil grid can emit more than a primary smelter drawing electricity from a hydro or nuclear grid. Remelters achieve exceptionally low emissions, but they cannot supply the volumes required by a growing market because they work with refined cathodes and only high-grade scrap rather than any available scrap.

For investors, policymakers and copper users, the message is clear. It is time to move beyond simple labels and interrogate the underlying drivers of carbon intensity. Focus on acquiring low-carbon electricity, improving furnace efficiency, recovering waste heat and gas, and optimising scrap supply chains. If you want to understand how a specific asset compares on the global carbon curve, or if you need to build a decarbonisation roadmap for your plant, we would be pleased to discuss our methodology and insights.

We welcome your questions and feedback



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Prior to joining Skarn, Sophie has led diverse, bespoke research and consulting projects in the metals and mining sector for Desjardin Capital Markets, Wood Mackenzie, Rio Tinto, CRU and Baringa.

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Tobias brings over 20 years of commercial leadership experience in high-growth B2B SaaS businesses, building and scaling go-to-market teams globally. Tobias leads all commercial functions, including sales, marketing and customer success. His focus is on accelerating adoption of Skarn's intelligence solutions and delivering sustainable, long-term value for customers across both the mining and financial sectors.

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