UK Critical Minerals Intelligence Centre

Waste and scrap flows in the UK: assessing copper and tungsten

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Waste and scrap flows in the UK: assessing copper and tungsten

G M Mudd, N Singh, I Watkins, R Halkes, D Currie, R Shaw, E Petavratzi, C Bishop, A Luce

Contributor/editor

J Mankelow, L Hannaford

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Front cover

Top right photo: wolframite, a tungsten mineral from Hemerdon, *TW 5d 16*, used with the permission of Tungsten West Plc

Bottom left photo: copper scrap, Alexas_Fotos. 2016. *copper-1504094_1280*. Pixabay

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British Geological Survey offices

Nicker Hill, Keyworth,
Nottingham NG12 5GG

Tel 0115 936 3100

BGS Central Enquiries Desk

Tel 0115 936 3143
email enquiries@bgs.ac.uk

BGS Sales

Tel 0115 936 3241
email sales@bgs.ac.uk

The Lyell Centre, Research Avenue South,
Edinburgh EH14 4AP

Tel 0131 667 1000
email scotsales@bgs.ac.uk

Natural History Museum, Cromwell Road,
London SW7 5BD

Tel 020 7589 4090
Tel 020 7942 5344/45
email bgslondon@bgs.ac.uk

Cardiff University, Main Building, Park Place,
Cardiff CF10 3AT

Tel 029 2167 4280

Geological Survey of Northern Ireland, Department for the Economy, Dundonald House, Upper Newtownards Road, Ballymiscaw, Belfast, BT4 3SB

Tel 0289 038 8462

www2.bgs.ac.uk/gsni/

Natural Environment Research Council, Polaris House,
North Star Avenue, Swindon SN2 1EU

Tel 01793 411500 Fax 01793 411501
www.nerc.ac.uk

UK Research and Innovation, Polaris House,
Swindon SN2 1FL

Tel 01793 444000
www.ukri.org

Website www.bgs.ac.uk
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Summary

Critical minerals are those crucial for a variety of modern technologies, infrastructure and industries but have global supply risks which need careful assessment to inform policy options and possible mitigations. This study was delivered by the United Kingdom (UK) Critical Minerals Intelligence Centre (CMIC) which is funded by the Department for Business and Trade (DBT) and hosted by the British Geological Survey (BGS). CMIC's primary objective is to support the UK Government's ambitions around resilient and sustainable critical minerals supply chains for the UK economy and needs.

The principal aims of this study were twofold: to assess copper and tungsten waste and scrap flows in the UK economy and to explore available economic and trade data to better understand how this could be used to inform circularity of resource use in the UK. Copper was chosen as a metal with widespread use but, given its diversified global supply, is not designated a critical mineral for the UK (whilst acknowledging concerns about the future of global copper mine supplies). Tungsten was chosen as it is designated a critical mineral for the UK; it has a concentrated global supply chain (dominated by China), the UK has one of the world's largest tungsten deposits (at Hemerdon in Devon) but parts of its supply chain remain an enigma due to poor data resolution.

The study demonstrates that for copper there are significant opportunities to reduce substantial copper losses contained in waste and scrap exports. Current exports of copper waste and scrap are valued at £1.06 billion yet the contained copper is worth £1.45 billion. This means that the UK is not capturing the value that the secondary copper resource represents, providing a major opportunity to improve the circularity of copper in the UK. At present, there are no refinery facilities to process secondary copper waste and scrap in the UK, meaning this is an important way that the UK could improve the circularity of its copper use. For tungsten, the study has shown that various uncertainties or inconsistencies remain in the available data, but the amounts of tungsten are typically modest and finding clear opportunities for improving circularity requires further research (especially extensive stakeholder engagement, collaboration and data synthesis).

The cases of copper and tungsten in the UK demonstrate that there are potentially significant opportunities for future improvement, including increased collection, separation, and functional recycling, as well as product development to reduce dissipation loss. Also, the waste and scrap from manufacturing processes may be managed in such a way that it can be kept for future use as a resource if new technology makes recycling it possible.

This study presents unique case studies on the current flows of copper and tungsten to and from the UK economy. The results provide a strong basis for demonstrating the benefits of improving circularity through new infrastructure, such as a secondary copper refinery. They also identify areas where more detailed research is needed, for example, tungsten circularity.

1 Introduction

A modern society relies upon a foundation of materials, metals and energy in order to function and achieve myriad objectives, such as economic growth, national security, social equity and net zero greenhouse gas emissions (Mudd et al., 2024). Societies have traditionally viewed their economy as a linear system that extracts, uses and disposes of materials, rather than a more sustainable (but more complex) system where there is a more circular system of reducting, reusing and recycling (Graedel, 1996).

There are many benefits to understanding material flows through an economy, including, amongst others:

- improving economic efficiency and productivity,
- reducing environmental impacts,
- resource efficiency,
- supply resilience,
- geopolitical issues at a global level (especially the implications of different resource flows between nations).

Noting the exception of aggregates and bulk minerals, the UK is primarily dependent on imports of raw materials, components and products. It is therefore important to understand where there are opportunities to reduce such reliance on material imports and improve the circularity and resilience of the UK's economic supply chains.

The 2024 UK Criticality Assessment, which assessed copper as a non-critical mineral for the UK, observed that there can be a variety of challenges in quantifying and assessing the flow of materials through the UK economy (Mudd et al., 2024). Particular challenges include quantifying the extent of recycling (a key component of circularity, albeit not the only one) or the combination of economic and other related statistical data. For example, from 2018 to 2022 the UK exported an average of 241 600 tonnes compared to average imports of 23 400 tonnes of copper waste and scrap. Given that this is likely to be high copper content material, this suggests that such activity makes the UK a net copper exporter through copper waste and scrap. It should be noted this is not a complete material flow analysis and does not explore other stocks and flows of copper or how this relates to UK copper demand. If this net export flow of copper contained in waste and scrap was incorporated into the calculation of UK net import reliance, a key indicator used to estimate UK economic vulnerability (one of the two primary components used to designate a critical mineral), the net import reliance for copper would reduce almost to zero. As a result, copper would move further away from the threshold for being deemed a critical mineral. The UK Critical Minerals Strategy released in November 2025 listed copper as a growth mineral due to its importance in supporting the numerous industrial strategy sectors to drive economic growth (UK Government, 2025).

Similarly, whilst tungsten was assessed as critical (Mudd et al., 2024) and is also listed as a growth mineral (UK Government, 2025), UK economic data states the UK produced an average of 19 500 tonnes tungsten (wolfram) and articles per year from 2020 to 2022. Average world tungsten mine production over this same time frame averaged 97 300 tonnes of tungsten. The UK, however, does not have the tungsten facilities and companies to achieve such production at the scale suggested by the economic data. If this UK economic data for tungsten were incorporated into the assessment of criticality, it would reduce the UK's net import reliance to nearly zero, moving tungsten below the criticality threshold to become non-critical.

Although these specific examples of copper waste and scrap and tungsten economic data were excluded from the 2024 UK Criticality Assessment (and similarly for some other commodities; Mudd et al., 2024), they remain worthy of further investigation to understand to what extent such data and insights might be able to be used in future criticality assessments. In other words, can waste and scrap data help with understanding the circularity of material use within the UK economy? To what extent can economic data help explain the UK situation for metals such as copper and tungsten? This report presents a deep dive into these two metals for these reasons.

1.1 PURPOSES OF THIS STUDY

The purposes of this study were twofold:

- to review UK copper and tungsten waste and scrap data, with a view to understanding their dynamics, metal contents and material flows into and out of the UK;
- to review UK economic and trade data[1] for copper and tungsten, with a view to validating their dynamics, metal contents and material flows into and out of the UK.

1.2 RESEARCH QUESTIONS FOR THIS STUDY

To achieve the purposes of this study, the following research questions for copper and tungsten need to be answered:

- What are the long-term trends in copper and tungsten waste and scrap flows into (imports) and out of (exports) the UK and how can they be explained?
- Given that copper and tungsten waste and scrap flows are likely to be complex mixes of various forms which vary over time, what are the most likely forms of copper and tungsten waste and scrap and what would be a reasonable basis for their metal content?
- To what extent can current economic and trade data inform the understanding of the circularity of resource use and efficiency in the UK, using copper and tungsten as examples?

[1] This report refers to data representing economic activity as economic data, while data for imports and exports are referred to as trade data.

2 Approach and methodology

2.1 OVERVIEW

Focusing on the period from 2000 to 2024, or older if required, this study involved a detailed synthesis and evaluation of trade, economic, and related data sources. Undertaken by a partial materials flow assessment focusing on specific data and supply chain stages (for example, trade data for copper waste and scrap, economic data for tungsten), the data from the following key sources were assessed:

- UK economic and related data
    - UK manufacturers' sales by product ('Prodcom'), 2024 survey (Office for National Statistics, 2025a)
    - UK trade information (HM Revenue & Customs, 2025a)
    - UK Waste Data Interrogator[2] (Environment Agency, 2024)
- UK and global trade data (imports; exports)
    - United Nations Comtrade (United Nations Statistics Division, 2025)
    - UK Minerals Yearbook (Bide et al., 2024) (including previous editions)
    - World Mineral Statistics (Idoine et al., 2024) (including previous editions)

These data sources were complemented by academic, industry and other relevant sources to provide additional lines of evidence, facilitate interpretation and support insights. When citing codes, an 'HS' code refers to UN Comtrade and 'CN' code refers to UK trade information.

The World Customs Organization developed the 'Harmonized System': 6-digit codes ('HS codes') that are used globally for identifying goods, particularly for trade statistics and applying international trade measures. The European Union (EU) classification for identifying traded goods builds upon the broad classification of goods offered by the HS code system via the addition of two EU-specific digits. The resulting 'Combined Nomenclature' eight-digit codes (CN codes) enable a more detailed classification of goods within the EU, particularly for import and export declarations and internal EU trade. The first six digits of a CN code therefore match the HS code, whilst the additional two digits provide more detailed product-specific information relevant to EU trade. The UK classification for the 'Trade in goods statistics' (TIGS) dataset aligns with the CN codes (HM Revenue & Customs, 2025b).

2.2 BACKGROUND AND FORMS OF COPPER

Copper (chemical symbol: Cu) has been a widely mined and used metal for millennia, with strong growth since the mid-1800s. The typical stages in copper's supply chain are:

- raw material extraction (mining; milling)
- processing to metal (smelting; refining)
- production of components and forms (wires; sheets; bars; etc)
- manufacture of final products.

These various supply chain stages are dispersed around the world, with some stages dominated by one or two countries (for example, Chile for mining; China for refining). This gives rise to an extensive suite of trade codes that cover the numerous forms of copper-related trade. This study investigates principal trade codes to build an understanding of which of the UK's copper flows relate to copper waste and scrap.

The study groups and assesses the most common forms of copper and their related economic and trade codes, shown in Table 1 (with a more detailed review of copper material flows given later). For more detailed descriptions of these forms and codes, see Appendix 15.3.

[2] https://environment.data.gov.uk/globalSearch?queryText=Waste%20Data%20Interrogator

Table 1 Principal copper-related economic and trade codes assessed in this study from UN Comtrade, UK trade information and UK Prodcom (HM Revenue & Customs, 2025a; Office for National Statistics, 2025a; United Nations Statistics Division, 2025).

Copper form	UN Comtrade (HS)	UK trade info (CN)	UK Prodcom	CN copper content (% Cu)	CN content source
Ores and concentrates	260300	26030000	07291100	28	Passarini et al. (2018)
Mattes	740110	74010000 74011000	24441100[A]	60	Schlesinger et al. (2011)
Cements	740120	74010000 74012000	24441100[A]	60	Schlesinger et al. (2011)
Sulphates	283325	28332500	20134165	30	Stoichiometric calculations and BGS internal calculation
Oxides and hydroxides	282550	28255000	20121200 20121240	80	Stoichiometric calculations and BGS internal calculation[B]
Chloride oxides and hydroxides	282741	28274100	20133150	65	Stoichiometric calculations and BGS internal calculation[B]
Unrefined	740200	74020000	24441200	99.5	Nakajima et al. (2018)
Slags, ash and residues	262030	26203000	no code	25	BGS internal calculation[B]
Waste and scrap	740400	74040010	no code	95	BGS internal calculation[B]
		74040091		65	
		74040099		75	

[A]Prodcom 24441100 ceased and moved to CN74010000 in 2006-07.

[B]BGS internal calculation refers to research undertaken at BGS to better approximate copper content for specific trade codes.

There are an extensive series of economic and trade codes for refined copper, including forms such as sheets, wires, bars, ingots, billets, powders and flakes, as well as alloys such as bronze (copper-zinc), brass (copper-tin), cupro-nickel (copper-nickel) and master alloys (various metals alloyed with copper). These metal forms are then worked into various configurations (for example, bars; rods; wires; plates) that are then transformed to products or parts (for example, tubes, pipes, machine components).

Copper waste and scrap can therefore include a wide range of sources and forms, so the metal content can vary significantly. For example, waste and scrap can come from (International Copper Study Group, 2021):

- copper smelters and refineries (such as discards, process losses or residues)
- 'new' scrap from cuttings, stampings, turnings or defects during the manufacturing of components and wrought forms (new scrap never enters the consumer market in final products)
- old scrap from used or worn-out components or products (such as castings, electronic scrap, copper-iron (Cu-Fe)-materials, catalysts, cables, pipes, etc.).

For this report with respect to copper, first-use products are generated from midstream materials, such as copper wires or rods. End-use products combine a variety of first-use materials to manufacture items for sale and use in the domestic market, such as an electrical transformer or electronic goods.

2.3 BACKGROUND AND FORMS OF TUNGSTEN

Tungsten (chemical symbol: W) emerged as an important metal for alloying with steel in the 1800s, and, by 1900, ferrotungsten (iron-tungsten) had entered commercial use for high-speed steels in cutting tools (Lassner and Schubert, 1999). From the 1920s, tungsten carbide (carbon-tungsten or 'hardmetal') emerged as a material with high toughness, strength and hardness suitable for complex machining and engineering applications (International Tungsten Industry Association, 2009).

Tungsten occurs in primary deposits and as a minor component in, for example, tin and molybdenum deposits, with most tungsten mined as a primary product. The principal stages include:

- extracting minerals during mining
- conversion to ammonium paratungstate (known as APT) or direct smelting to ferrotungsten
- processing to metal powders, ammonium metatungstate (known as AMT) or tungsten acids or oxides
- manufacture of components or products such as drill bits, lamps, ammunition, tools, machines, vehicles, etc.

Given its specialised nature, the global tungsten supply chain is more concentrated than that of copper, with considerably fewer economic and trade codes. It should be emphasised, however, that considerable quantities of tungsten would be hidden within codes for materials, components and products that contain small amounts of tungsten (especially considering the wide range of products that use ferrotungsten alloys or tungsten carbide).

This study groups and assesses the most common forms of tungsten and their related economic and trade codes, shown in Table 2 (with a more detailed review of tungsten material flows given later). For more detailed descriptions of these forms and codes, including discussion of tungsten code changes over time in UN Comtrade, see Appendix 1.

Some tungsten forms are not captured by the codes listed in Table 2. For example, tungstic acid (H_2WO_4 or $H_2O{\cdot}WO_3$) is produced from the decomposition of ammonium paratungstate (APT) with a mineral acid (for example, hydrochloric acid) (International Tungsten Industry Association, 2025a) or the mineral acid decomposition (for example, hydrochloric acid) of scheelite or synthetic scheelite ($CaWO_4$, which is derived from the hydrometallurgical

processing of impure wolframite concentrates) (Shen et al., 2019). Tungstic acid has a small market and is used for producing ultrafine (sub-micron scale) tungsten powder, tungsten carbide, tungsten chemicals, and a pigment for bright yellow glass (International Tungsten Industry Association, 2025a; Lassner and Schubert, 1999). There are two varieties of tungstic acid, namely white or yellow tungstic acid. Traded tungstic acid typically contains between 92 and 94 per cent tungstic trioxide (73.0 and 74.5 per cent tungsten) (H C Starck Tungsten Powders, 2025).

For this report with respect to tungsten, intermediate forms are referred to as first use whilst components or products containing tungsten are considered as end uses. For example, ferro-tungsten is an intermediate product (midstream stage) used to produce superalloys that contain tungsten (downstream stage), which are then utilised in the aerospace, industrial and maritime industries (downstream stage). First-use products can include some of the forms captured here, including tungsten wire, profiles, plates, sheets, strip and foil, which are all used to manufacture product components further downstream.

Table 2 Principal tungsten-related economic and trade codes assessed in this study from UN Comtrade, UK trade information and UK Prodcom. Developed from HM Revenue & Customs (2025a), Office for National Statistics (2025a), United Nations Statistics Division (2025).

Tungsten form	UN Comtrade (HS)	UK Trade Info (CN)	UK Prodcom	HS tungsten content (% W)	HS content source	CN tungsten content (% W)	CN content source
Ores and concentrates	261100	26110000	07291920	55	Lassner and Schubert (1999)	55	Lassner and Schubert (1999)
Oxides and hydroxides	282590	28259040	20121981	[A]	H C Starck Tungsten Powders (2025)	76	H C Starck Tungsten Powders (2025)
Ammonium paratungstate (APT)	284180	28418000	20135115	70.2	H C Starck Tungsten Powders (2025)	70.4	Stoichiometry calculation
Ammonium metatungstate (AMT)				72.2		72.8	Stoichiometry calculation
Ferroalloys	720280	72028000	24101250	77	Lassner and Schubert (1999)	77	Lassner and Schubert (1999)
Powders	810110	81011000	24453013	99.9	H C Starck Tungsten Powders (2025)	100	H C Starck Tungsten Powders (2025)
Carbides	284990	28499030	20136430	[B]	Stoichiometry, H C Starck Tungsten Powders (2025)	93.9	Stoichiometry calculation
Unwrought bars and rods obtained by sintering	810194 810191 – discontinued since 2002	81019400	24453013	99.95	Elmet Technologies (2025); Luoyang Focus W & Mo Technology Company Ltd (2025)	100	Elmet Technologies (2025); Luoyang Focus W & Mo Technology Company Ltd (2025)
Unwrought bars and rods not obtained by sintering	810192	81019910	24453013			94	HM Revenue & Customs (2022)
	810195	81019990				90	BGS internal estimate[C]

Tungsten form	UN Comtrade (HS)	UK Trade Info (CN)	UK Prodcom	HS tungsten content (% W)	HS content source	CN tungsten content (% W)	CN content source
Wires	810196 810193 – discontinued since 2002	81019600	24453013	99.95	Elmet Technologies (2025); Luoyang Focus W & Mo Technology Company Ltd (2025)	100	Elmet Technologies (2025); Luoyang Focus W & Mo Technology Company Ltd (2025)
Halogen filament lamps	853921	85392130	27401250	[D]	BGS internal calculation[C]	0.07	BGS internal estimate[C] based on filament composition and weight of lamps
		85392192	27401293			0.06	
		85392198	27401295			0.01	
Slags, ash and residues	262099	26209995	no code	90	BGS internal calculation[C]	[E]	
Waste and scrap	810197	81019700	no code	60	BGS internal calculation[C]	60	BGS internal estimate[C] based on widely used tools and components containing 30-99% W
Miscellaneous	810199	81019910	24453013	90	BGS internal calculation[C]	94	HM Revenue & Customs (2022)
		81019990				90	BGS internal estimate[C]

[A]UN Comtrade HS282590 code monitors trade of calcium, beryllium, tin, mercury, cadmium and other or not elsewhere specified inorganic base and metal oxides, hydroxides and peroxides as well as tungsten oxides and hydroxides. A UK trade information share of the trade code was applied to UN Comtrade data to estimate the mass and value of tungsten oxides and hydroxides contained within this code with tungsten content of 79 per cent from H C Starck Tungsten Powders (2025).

[B]UN Comtrade HS284990 code monitors trade of boron, tungsten, aluminium, chromium, molybdenum, vanadium, tantalum, titanium and other carbides whether or not chemically defined. A UK trade information share of the trade code was applied to UN Comtrade data to estimate the mass and value of tungsten carbides contained within this code. Tungsten content of 94 per cent was applied to traded net weight.

[C] BGS internal calculation refers to research undertaken at BGS to better approximate tungsten content for specific trade codes.

[D]UN Comtrade HS853921 code monitors the trade of tungsten halogen filament lamps, excluding ultraviolet or infrared lamps. A UK trade information share of the trade code was applied to quantify the mass and value of the three types of lamps monitored in UK trade information, including tungsten halogen filament lamps for motorcycle or motor vehicles (CN85392130), tungsten halogen filament lamps for a voltage either less than or equal to 100V (CN85392198) or greater than 100V (CN85392192). Metal contents of the respective CN codes were applied.

[E]This CN code is a catch-all category for metal-containing residues not dominated by the metals that are tracked: tungsten, molybdenum, cobalt, vanadium, magnesium and manganese. Due to this broad categorisation, it is not possible to determine an exact composition or a realistic range for tungsten content.

3 Framing material flows for assessment

It is important to understand the complete supply chain of a material to place the flows of waste and scrap in their proper context. Such an assessment is known as a material flow analysis (MFA), a widely used approach to assess and quantify materials and their stocks and flows over time through an economy or region. This study, however, only explores material flows associated with certain trade and economic codes; it is not conducting a comprehensive MFA.

To better understand the codes and data that have been analysed, the global supply chains for copper and tungsten are reviewed to set the scene for each element's flows in the UK, especially in respect to waste and scrap. Three principal material flow stages are adopted:

- raw materials extraction (mining; smelting; refining)
- intermediate processing (conversion to different forms; component and product manufacture)
- downstream use and end-of-life (products; disposal or recycling).

It is also important to review whether the various trade and economic codes facilitate the ability to better quantify the extent of recycling or circularity within the respective supply chains for copper and tungsten.

3.1 COPPER

3.1.1 Review of the global copper sector

Copper is an essential material for modern society and a more sustainable future, especially for the energy transition. Its physical characteristics such as exceptional conductivity, corrosion resistance, strength, and recyclability make it a key material in domestic, industrial, and high-technology applications. Given these characteristics, copper is fundamental for electricity generation, distribution, and storage. This is particularly important given the global transition to a renewable energy-based system aimed at achieving net zero emissions. Typically, global copper use is spread across (data combined from International Copper Association (2022) and Idoine et al. (2025)):

- 44 per cent in the power grid (about 12.1 million tonnes)
- 20 per cent in the construction industry (about 5.5 million tonnes)
- 14 per cent in the electrical and electronics sectors (about 3.9 million tonnes)
- 12 per cent in transportation (about 3.3 million tonnes)
- 10 per cent in consumer goods like coins, jewellery, and household items (about 2.8 million tonnes).

Growing global demand for copper is being driven by its role in energy infrastructure (especially renewable energy), transport (particularly electric vehicles (EVs)) and digital technologies, leading to some concerns about future supply keeping pace (International Energy Agency, 2025). Studies suggest that demand for copper for use in clean technology will increase by 57 per cent between 2024 and 2040. Copper demand across all uses is anticipated to increase by 27 per cent whilst secondary copper supply increases by 96 per cent over the same period (International Energy Agency, 2025).

Battery EV's (BEVs) average around 70 kg copper per vehicle, around 45 kg more than internal combustion engine (ICE) vehicles. The shift to BEVs and the amount of copper needed compared to ICEs has led to forecasts of up to a 177 per cent increase in copper demand from the EV and battery sector by 2030. However, the mass of copper used in BEVs is forecast to decrease by 38 kg per vehicle between 2015 and 2030, including charging cables, potentially alleviating some of the predicted demand increase (Benchmark Source, 2024). This is expected to be a function of more efficient engineering designs and manufacturing.

Primary copper supply is expected to peak by the late 2020s and steadily decline into the mid-2030s due to falling ore grades, mine closures and reserve depletion (International Energy Agency, 2025), unless new mines are developed or existing mines expand in capacity. The declining pace of new copper deposit discoveries, coupled with the lengthy average timeline of 17 years (as of 2023) from deposit discovery to mine production, is raising serious concerns about the reliability of future primary copper supply (Farrell and Whitton, 2024). A 35 per cent supply gap is currently predicted under the International Energy Agency's 'Announced Pledges Scenario', where governments meet their national energy, climate, and emissions targets in full and on time (International Energy Agency, 2025). Even in high primary production scenarios, a 20 per cent shortfall is expected by 2035 (International Energy Agency, 2025).

In the most recent UK criticality assessment, copper received a criticality score of 3.4; which is below the 4.0 threshold required for classification as a critical mineral un the UK (Mudd et al., 2024). This score was influenced by the relative maturity and global diversification of the copper market, along with the presence of a substantial secondary market.

However, it is expected that greater copper supply will come from the Democratic Republic of the Congo (DRC) and Zambia, both countries with lower environmental, social, and governance (ESG) ratings than major producers such as Chile or the USA, which raises concerns about security of future supply (Sustainalytics, 2025). Additionally, over half of known copper mines are in regions experiencing high water stress, further contributing to copper's criticality profile from an ESG perspective (International Energy Agency, 2024; Northey et al., 2017). It should be noted, however, that ESG issues can change over time. For example, governance can improve over time (e.g. adoption of voluntary standards such as The Copper Mark), providing for better ESG outcomes. Alternatively, water stress may increase due to climate change, putting significant pressure on water resources and thereby communities who depend on shared water resources. All of this means that there are grounds for concern that the criticality of copper could increase in the future.

3.1.2 Material flow system and supply chain for copper

The material flow system for copper begins with raw material extraction and processing. This typically involves an open pit or underground mine and ore processing mill (for example, flotation), leading to a copper-rich concentrate. The concentrate is smelted to produce copper anode, blister copper or copper-rich matte, all of which are further refined to pure copper metal (typically 99.95 per cent copper cathode, such as the London Metal Exchange Grade A standard). Alternatively, ore can be processed using heap leaching, whereby acid solutions are passed through an engineered heap of copper ore and the resultant copper-rich solution refined directly to copper cathode.

Refined copper metal then moves through a variety of possible intermediate processes that convert the copper to components, such as tubes, wires, bars, rods, plates, chemicals, etc. These copper components are ultimately incorporated into various final products, such as electrical or telecommunications equipment and cables, home appliances, EVs, and more. Products containing copper represent the downstream stage, which finishes when the product reaches its end-of-life ('EoL') and is either recycled or sent for disposal.

Figure 1 shows the high-level material flow system for copper and represents the principal stages and individual steps within each stage along copper's journey from ore in the ground to a product, followed by recycling or disposal. Figure 2 shows a global flow chart as a Sankey diagram and is based on data for the three principal stages of copper's material flow system.

A more detailed review of the raw material extraction stages is given in Appendix 2. Although the UK has a long and globally significant history of copper mining and smelting from the 17th to early 19th centuries, it has not mined copper since 1991 when copper was a by-product of tin mining. This study focuses mostly on the downstream stage, which has the most relevance for understanding copper waste and scrap flows.

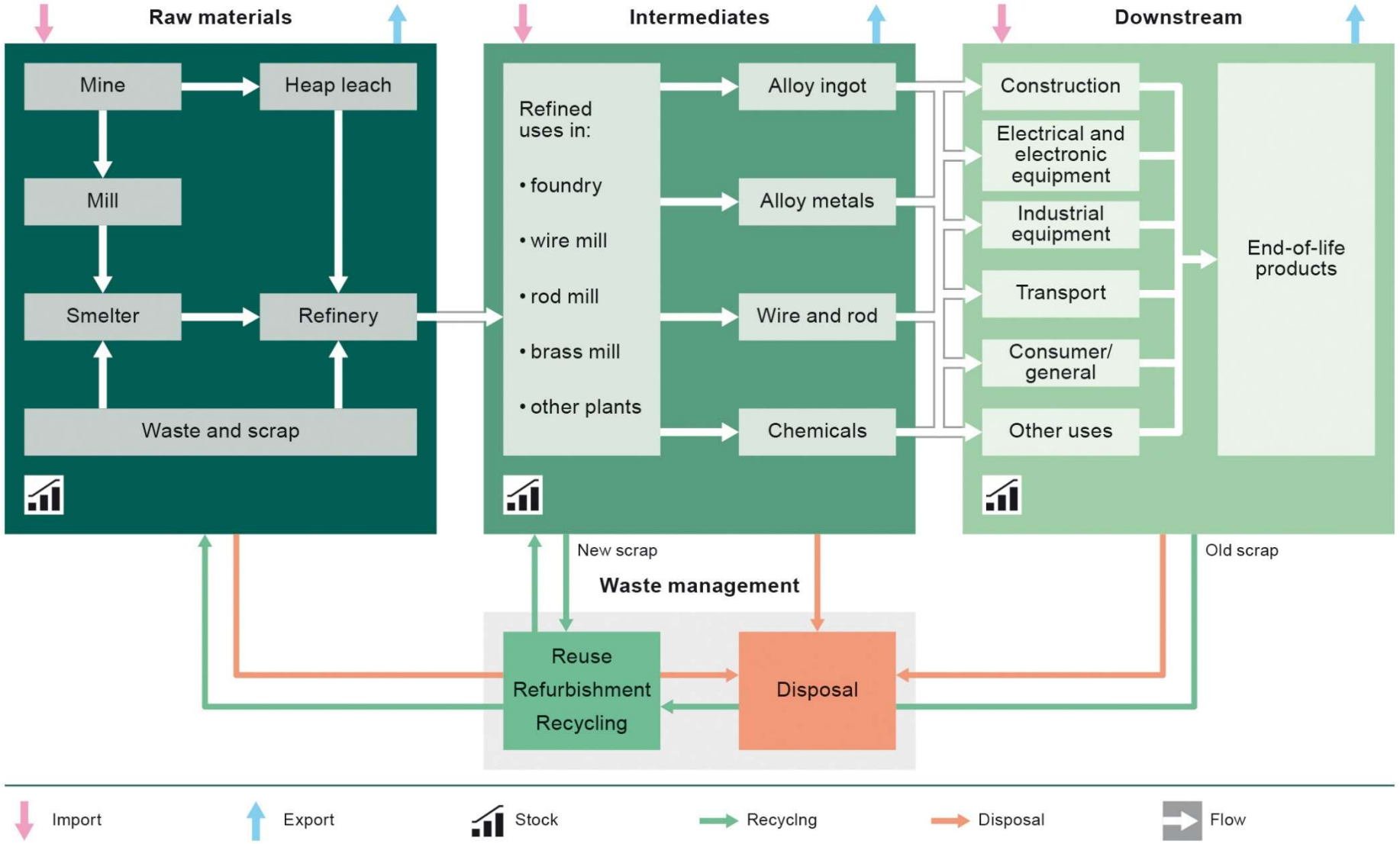

Figure 1 Material flow system for copper at a global level. Created by BGS based on expert knowledge and information from International Copper Study Group (2024).

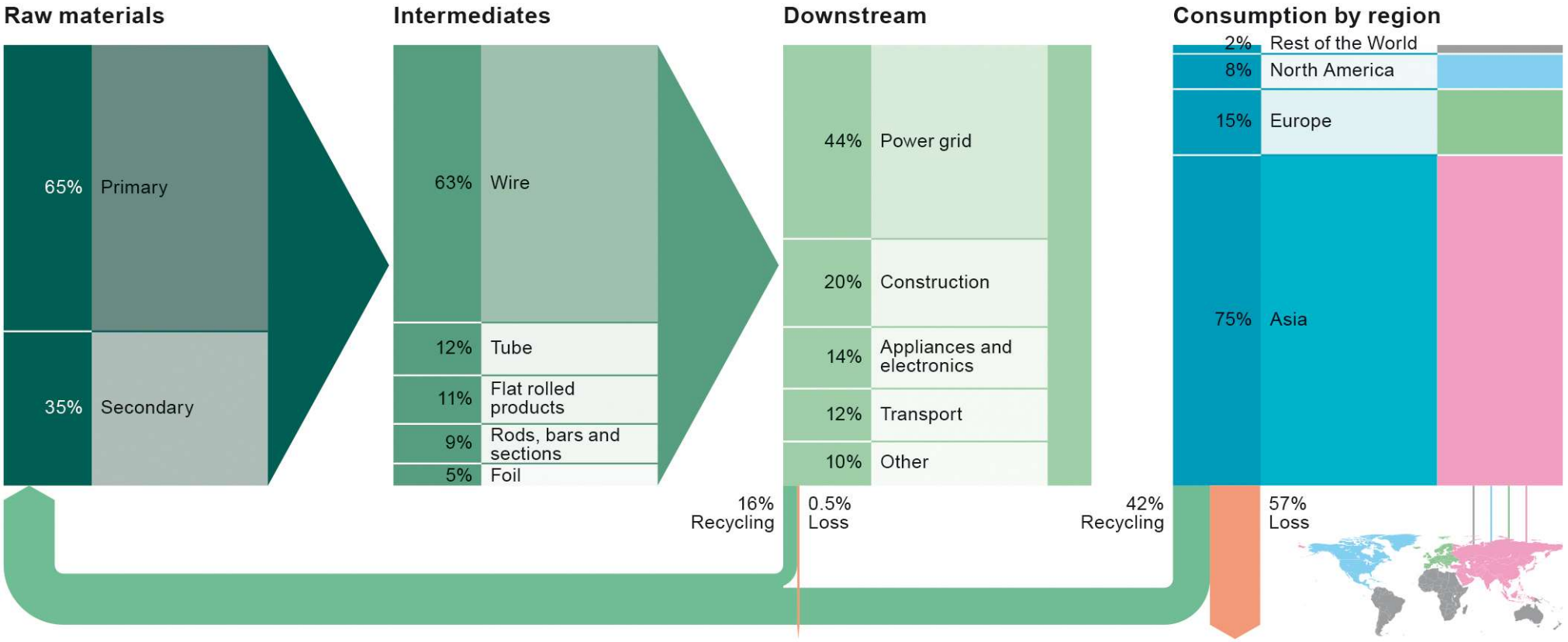

Figure 2 Sankey diagram of global copper flows and the regions that consumed the most of copper annually. Created by BGS based on data from International Copper Association (2022) and International Copper Study Group (2024).

3.1.3 Reprocessing and secondary copper

Copper is generally readily recyclable and can be reprocessed repeatedly without any loss in performance (subject to removing impurities in products or from use). The recovery of copper from waste and scrap — known as secondary copper — now accounts for about one third of the copper entering the global market, much of which has already been recycled at least once.

Three categories of copper waste and scrap can arise:

- home scrap (during production)
- new scrap (manufacturing)
- old scrap (after consumer use)

Disused products that are discarded in landfills present a potential future source of copper (Schlesinger et al., 2011).

Home scrap includes off-specification anodes, cathodes, bars, and rods, which are returned to the furnace for reprocessing. New scrap, often altered by coatings or alloying, is re-melted and recast, preserving valuable alloying elements like zinc, tin or nickel. Old scrap, also called obsolete or post-consumer scrap, is the most challenging to process due to its lower copper content, dispersed sources, and inconsistent quality due to a range of impurities present (Schlesinger et al., 2011). Old scrap is categorised into the six classes shown in Table 3.

Table 3 Copper content per waste classification of old scrap (Schlesinger et al., 2011).

Old scrap waste class	Copper content (% Cu)
End-of-life vehicles (excluding aircraft, ships and trains)[A]	1 – 2.1
Construction and demolition waste	0.3
Waste electrical and electronic equipment: • white goods (domestic appliances) • brown goods (TVs; DVD players; etc) • grey goods (computers; telecoms)	2 – 20
Industrial electrical equipment waste: • power cables • transformers • other electrical equipment	5 – 80
Industrial non-electrical equipment waste: • aircraft, ships, and trains • spent ammunition and ordnance • other machinery	Low
Municipal solid waste (for example, loose coins; discarded wires)	0.05 – 0.20

[A]Further details provided in Appendix 2.

Globally, it is thought that around 8.7 million tonnes Cu comes from recycling of copper waste and scrap each year, representing about one third of total copper supply (International Copper Association, 2022). The reduction in energy required for recycling copper as opposed to primary production may be up to 90 per cent (International Copper Association, 2023). Recycled copper supply is projected to increase to 40 to 45 per cent of global copper demand by 2050 (The Copper Mark, 2024). The top five countries and world totals for imports and exports of copper waste and scrap for the year 2024 are given in Table 4.

Table 4 Top 5 countries for the import and export of copper waste and scrap for 2024 (data UN Comtrade; United Nations Statistics Division, 2025)

Flow	Rank	Country	Quantity tonnes	Value US$	Value US$/tonne
Export	1st	United States of America	959 347	$5 380 562 874	5 609
	2nd	Germany	398 668	$2 446 977 722	6 138
	3rd	Japan	340 475	$2 432 390 522	7 144
	4th	France	238 281	$1 563 988 959	6 564
	5th	United Kingdom	279 413	$1 692 498 973	6 057
		World Total	**5 057 401**	**$30 121 160 466**	**5 956**
Import	1st	China	2 247 358	$17 813 243 667	7 926
	2nd	Germany	460 102	$3 163 768 111	6 876
	3rd	India	329 084	$2 036 721 942	6 189
	4th	Republic of Korea	298 711	$2 410 588 540	8 070
	5th	Belgium	287 257	$1 971 121 334	6 862
		World Total	**5 501 228[A]**	**$39 334 757 949[A]**	7 150

[A]United Kingdom imports in 2024 were 24,508 tonnes valued at US$143,658,167 (value $5,862/tonne).

Copper waste and scrap with a purity of 88 to 99 per cent Cu can be subjected either to direct melting in a single-stage furnace or a multi-step metallurgical refining sequence. This may involve fire refining followed by electrorefining to achieve high-purity cathode copper, prior to downstream processes such as continuous casting, fabrication, and material recovery. Lower-purity scrap (less than 88 per cent Cu) must go through several processes to reach ‘rough copper’ grades of more than 95 per cent Cu prior to fire refining and electrorefining, casting, and fabrication (Schlesinger et al., 2011).

Copper recovery from waste and scrap often requires physical separation. For example, common copper-containing wires and cables typically consist of three main components: a conductive copper core, an insulating layer of polymers such as polyvinyl chloride or polyethylene, and a flame-retardant protective layer (Suresh et al., 2017). Copper recovery from scrap wire and cables therefore usually involves shredding and separating into three fractions: a pure plastic fraction, material meeting certain scrap purity thresholds, and a ‘middlings’ fraction that is then reprocessed. Air table separators can recover around 80 to 90 per cent of copper from old scrap. In larger operations, elutriation or electrostatic separation is sometimes used as an extra step to recover additional copper from the plastic fraction.

Recovery of copper from waste and scrap is not a straightforward process. Recent challenges in copper recycling in North America and Europe were highlighted by Loibl and Tercero Espinoza (2021). Their study concluded that the complexity and miniaturisation of modern products were complicating recycling. It also recommended that manufacturers and recyclers must implement a ‘design for recycling’ collaboration to enable more effective recycling of copper-containing products.

3.2 TUNGSTEN

3.2.1 Review of the global tungsten sector

Tungsten is a hard, very dense, rare metal. Tungsten does not occur naturally as a free (or native) metal but is found mainly in the minerals wolframite, scheelite ferberite, and gübnerite, with basic properties given in Table 5. Tungsten is categorised as a critical mineral in the EU, USA, UK and other major countries (Mudd et al., 2024).

Table 5 The most common tungsten minerals and their properties (Pitfield and Brown, 2011).

Name	Formula	Tungsten content (%)		Specific gravity (g/cm^3)	Appearance (colour and lustre)	Crystal structure
		WO_3	W			
Ferberite	$FeWO_4$	76.3	60.5	7.5	Black, sub-metallic to metallic	Monoclinic
Hübnerite	$MnWO_4$	76.6	60.7	7.2-7.3	Red-brown to black, sub-metallic to adamantine	Monoclinic
Scheelite	$CaWO_4$	80.6	63.9	5.4-6.1	Pale yellow to orange, green to dark brown, pinkish-tan, dark blue to black, white or colourless, vitreous or resinous	Tetragonal
Stolzite	$PbWO_4$	50.9	40.4	8.28	Reddish-brown to yellow-green, sub-adamantine to resinous	Tetragonal
Wolframite	$(Fe,Mn)WO_4$	76.5	60.7	7.1-7.5	Dark grey to black, sub-metallic to metallic	Monoclinic

Tungsten is an indispensable element for many essential industries, such as defence, transport, mining, and construction due to its (Brown and Pitfield, 2014):

- refractory nature
- extreme strength
- very high melting point
- very high density
- high wear resistance
- high tensile strength
- low coefficient of expansion
- high thermal and electrical conductivity
- capacity to make superalloys with iron (ferrotungsten) or carbon (tungsten carbide)

A reliable tungsten supply is vital for industries and strengthens national security by reducing reliance on the small number of producing countries. Tungsten supply concerns are being evaluated in numerous economies due to supply and demand imbalances, geopolitical events, and environmental and public health issues (Zheng et al., 2025).

Major tungsten deposits occur in many parts of the world, but the largest mines and/or reserves are known in China, Australia, Russia, Vietnam and Spain. Many other countries have mined tungsten historically (such as Portugal and the USA), currently mine tungsten on a small to modest scale or have proven deposits (such as North Korea, Austria, Portugal, Rwanda,

Bolivia) (United States Geological Survey, 2025). Most tungsten occurs in primary deposits on its own, but it can also be found in association with tin or molybdenum deposits where tungsten can be extracted as a by-product, although the mineralogy is still mostly wolframite or scheelite.

Mining methods are determined by the deposit's physical and chemical qualities, tonnage, grade, orebody geometry and depth. Common mining methods include open pit, underground or both (Brown and Pitfield, 2014). The first step in processing the ore is beneficiation at the mine site to extract a high-grade tungsten mineral concentrate that typically contains around 65 per cent tungsten trioxide (WO_3). This can then be used directly to produce ferrotungsten, converted to several intermediate tungsten compounds through hydrometallurgical processes, or further refined to pure tungsten metal using pyrometallurgical techniques.

Although current tungsten demands are reasonably well understood, there are no reliable demand forecasts available at present which explore the future landscape for tungsten demand.

3.2.2 Material flow system and supply chain for tungsten

Tungsten is used and traded in a variety of forms. The most commonly described are (HM Revenue & Customs, 2025a):

- ammonium para-tungstate (APT)
- ammonium meta-tungstate (AMT)
- tungsten trioxide, tungsten oxides (yellow or blue oxides)
- tungsten metal powder
- tungsten carbide
- tungsten alloys
- ferrotungsten
- non-ferrous tungsten alloys
- superalloys
- tungsten chemicals

The raw materials extraction process from tungsten to finished product generates important tungsten intermediate products that have unique properties, are traded internationally, and are typical of the tungsten business. Many have uses in their own right, for example (International Tungsten Industry Association, 2025a):

- APT can be used as a colorant in the porcelain industry or in catalysts, phosphors, and absorbent gels;
- AMT can be used as a reagent for chemical analysis during medical diagnosis or as a corrosion inhibitor;
- tungsten trioxide (WO_3) can be used as a catalyst or pigment in ceramics and paint.

Other materials containing tungsten have a wide range of applications. For example, sodium tungstate (Na_2WO_4) is a common tungsten chemical used in the production of organic dyes and pigments, catalysts, fireproofing of textiles and as a hard surface for graphite crucibles. Tungsten hexafluoride (WF_6) gas is commonly utilised in the manufacture of semiconductor circuits and circuit boards by chemical vapour deposition. The semiconductor industry consumes 87 per cent of total tungsten hexafluoride applications per year but this represents less than 2 percent of annual tungsten demand (Market Growth Reports, 2015). Tungsten hexafluoride is also used to deposit tungsten coatings on ceramics or metal items, such as bearings.

Figure 3 shows the high-level material flow system for tungsten and represents the principal stages or steps along tungsten's journey from ore in the ground to a product and then recycling or disposal. A global flow chart based on data for the three principal stages of tungsten's material flow system is shown as a Sankey diagram in Figure 4.

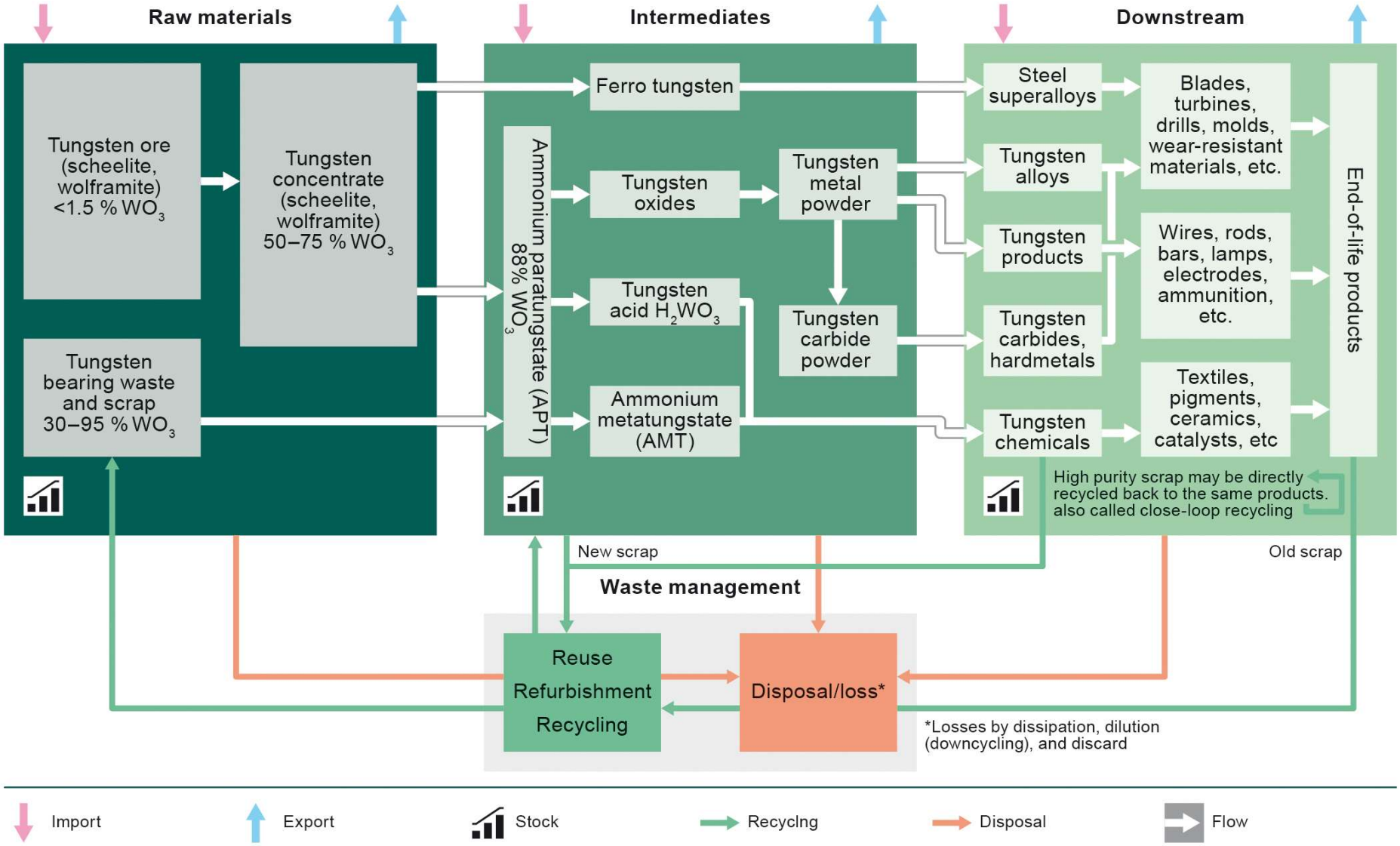

Figure 3 Material flow system for tungsten at a global level. Created by BGS based on expert knowledge and information from International Tungsten Industry Association (2025c) and Liang et al. (2022). BGS © UKRI 2025.

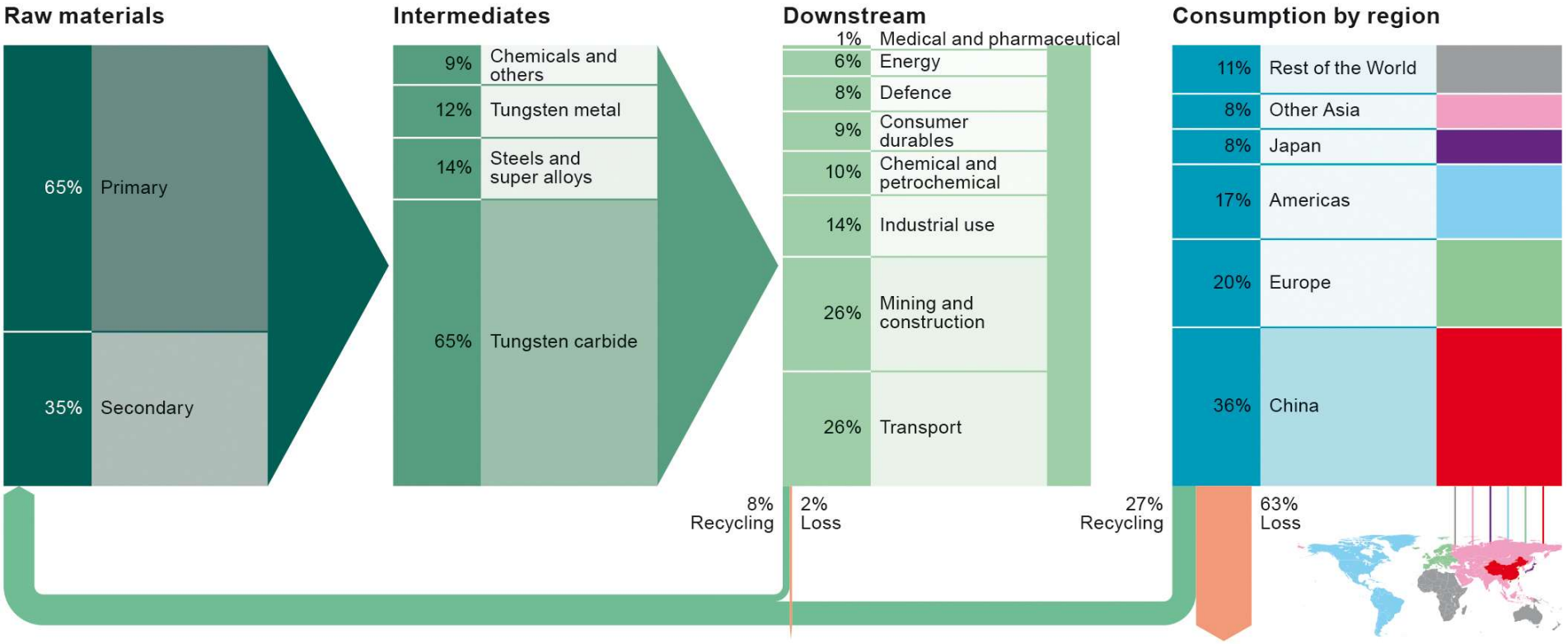

Figure 4 Sankey diagram of global tungsten flows and the regions that consumed the most of tungsten annually. Created by BGS based on data from International Tungsten Industry Association (2025b).

Tungsten applications can be categorised from either the material perspective, based on tungsten intermediate material type and products thereof (first use) or the industry in which they are finally used (end use). First use applications are the first downstream production step using tungsten intermediates (Figure 3). Tungsten carbide products represent almost two-thirds (65 per cent) of total global consumption (Figure 4).

All of the first use tungsten-based materials are ultimately used in different industries and end use applications. For example, a tungsten carbide metal-machining cutting insert can be used to process:

- turbine blades of an airplane engine
- a passenger car's gear drive
- parts of a wind turbine for electrical power generation
- injection moulding tools for children's toy production

These end uses, although based on the same first use product, can have completely different demand and growth perspectives. Therefore, an in-depth analysis of each end use is necessary to be able to determine the current demand for tungsten and predict future demand (International Tungsten Industry Association, 2025a). The International Tungsten Industry Association (2024) reports that tungsten's end use consumption can be summarised as (Figure 4):

- just over half is for transport, mining and construction
    - three-quarters of the transport segment is automotive, making this industry the single biggest tungsten consumer worldwide (about 16 700 tonnes W)
    - within mining and construction, 62 per cent goes into mining (about 13 800 tonnes W), with the majority used in underground mining
- about 8 per cent is used within defence technologies and infrastructure

By region, China consumes about 36 per cent (about 30,850 tonnes W), followed by:

- Europe (20 per cent; about 17 140 tonnes W)
- the Americas (17 per cent; about 14 570 tonnes W)
- Japan and other Asia (8 per cent each; about 6 860 tonnes W)
- Rest of the world relatively evenly distributed (11 per cent; about 9 430 tonnes W)

Tungsten has seen an increase in global demand as new uses and applications emerge and international manufacturing expands. Between 2007 and 2021, the compound annual growth rate was 3.4 per cent, notwithstanding the effects of the global economic crisis and COVID-19 (International Tungsten Industry Association, 2025b). In addition, an increased demand for tungsten is anticipated due to its use in green technologies like EVs and wind turbines (SFA Oxford, 2025; Eureka, 2015).

Over the past few decades, there has been a significant surge in efforts to move the tungsten sector toward circularity. With a current recycling rate of around 35 per cent globally, tungsten belongs to the group of metals with a recycling input rate greater than 25 per cent. Such a rate, according to United Nations Environment Programme et al. (2013), is only reached by one-third of the 60 metals studied.

Whilst waste and scrap from tungsten production processes are collected and almost entirely recycled (primarily related to its high value), EoL tungsten-containing products are mostly lost either by dissipation and dilution or unaccounted discarding – meaning this tungsten is lost and not available for recycling. This provides opportunities for future improvement, including increased collection, separation, and functional recycling, as well as product development to reduce dissipation loss. Also, waste and scrap from manufacturing processes may be managed in such a way that it can be kept for future use as a resource if new technology makes recycling it possible. In practice, this means establishing stocks to store such materials until technological progress and economic conditions favours processing and recovery.

The global supply of tungsten is largely dependent on Asia, particularly China, which has long been a dominant player in tungsten ore and primary processing. Vietnam currently ranks second, with Russia the third-largest producer of tungsten ore and concentrate and contributes, on average, about 3 per cent of global supply. Historical world tungsten mine production is shown in Figure 5, grouping by major geographical regions.

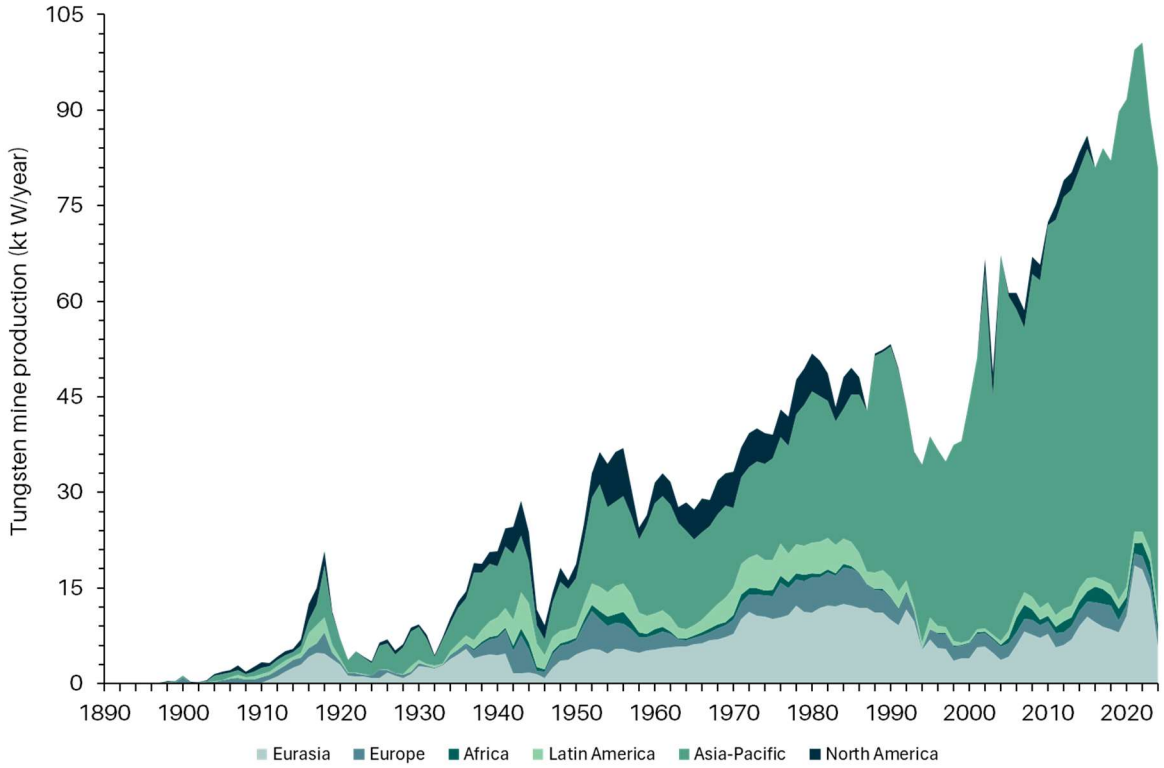

Figure 5 Historical world tungsten mine production by principal regions (in thousand tonnes (kt) contained tungsten). Data synthesized from Idoine et al. (2025), Anonymous (various), Schmitz (1979), United States Bureau of Mines (various) and United States Geological Survey (various) including previous editions. BGS © UKRI 2025.

Historically, the UK was (until 1991) a modest but regular producer of tungsten. Production was largely associated with tin mining in Devon and Cornwall, with minor amounts in the Lake District. During the mid-2010s, a new mine, process plant and infrastructure were built at the Drakelands site in Devon, with production starting in August 2015, although technical and financial difficulties forced closure in October 2018 after only a few years of production (Tungsten West, 2025). The concentrates were to be exported to the companies Global Tungsten and Powders in the USA or Wolfram Bergbau und Hütten in Austria (Wolf Minerals Ltd, 2015).

Recent research has addressed the previous issues and Tungsten West Plc, the new owner of the mine (reverting to its original name of Hemerdon), is looking to restart operations. Hemerdon is considered one of the largest tungsten deposits in the world, especially outside of China. The project is expected to include facilities for crushing, water-based suspension and separation, drying, and reduction, with tungsten concentrates processed in Austria or the USA (Department for Business and Trade, 2025). Although Hemerdon would provide a domestic source for tungsten concentrates, the intermediate stages would occur overseas, highlighting the need to understand all stages of the tungsten supply chain to achieve the best resilience in tungsten supply.

4 Results

This section presents the results of an analysis of copper and tungsten waste and scrap flows in the UK, derived from numerous sources of economic and trade data. A descriptive comparison of Prodcom and UK trade information codes, including notes on UK production and notable companies is provided for reference in Appendix 3.

4.1 COPPER

Copper remains a widely used metal throughout the UK economy, highlighted by significant economic activity and value associated with numerous ‘Prodcom’ (UK manufacturers' sales by product) codes and substantial imports and exports of copper and copper-containing products (Table 1).

4.1.1 UK Prodcom

There is no specific copper waste and scrap code in Prodcom, although there are many relating to the various forms of copper across its supply chain, such as unrefined and refined copper, bars, rods, wires, sheets, alloys, unwrought / wrought, etc. Of these, several codes have zero data reported, suggesting no economic activity for these forms in the UK (for example, 24441100 copper mattes and cements; 24441200 unrefined copper).

Others have mostly suppressed data, which means there are very few companies reporting under this code and suppression protects commercial sensitivity of business activity (24441330 unwrought copper, amongst others). Some codes have variable data reported, often including some years of suppressed data (24441370 unwrought copper alloys, amongst others).

The overall level of economic activity can be explored through standard industry code (SIC) 2444, which represents the overall value of copper-related production in UK manufacturers sales. From 2008 to 2023, this averaged about £536 million per year, ranging from £428 million to £727 million per year, as shown in Figure 6.

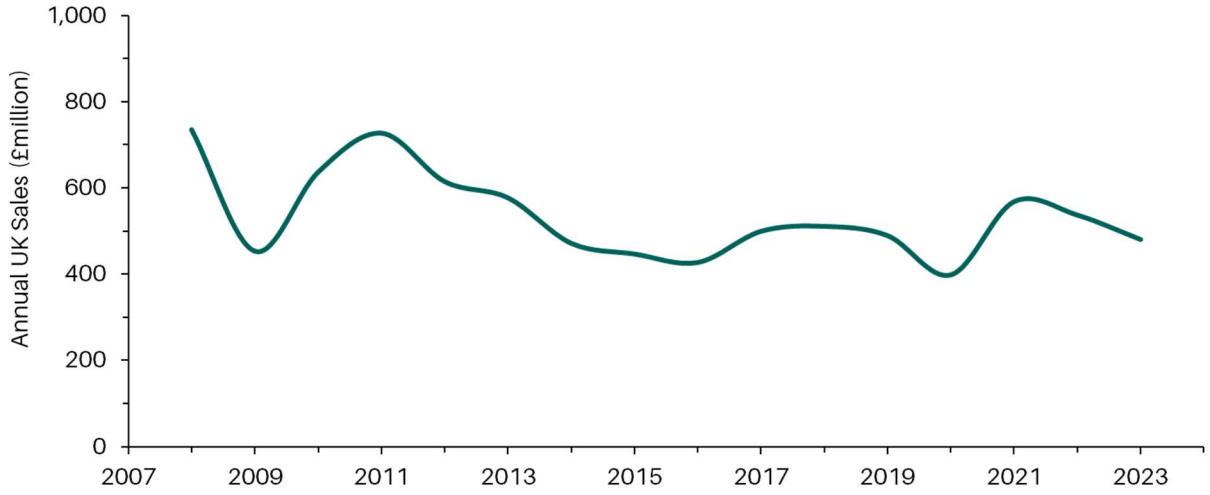

Figure 6 Annual UK manufacturing sales vale in £million under copper production in Prodcom, SIC 2444 (Office for National Statistics, 2025a). BGS © UKRI 2025.

4.1.2 UN Comtrade

The HS code for copper waste and scrap in UN Comtrade is 740400, with import and export data available from 1993 to 2024. In addition, copper waste and scrap data are reported in the UK Minerals Yearbook (Bide et al., 2024) as well as World Mineral Production (Idoine et al., 2025), both published by BGS, including all historical editions. The most recent data (1993 to 2024) are consistent between Comtrade, UK Minerals Yearbook and World Mineral Production, giving a coefficient of correlation of 0.999 for exports and 0.992 for imports (data and analysis not included herein). Given this strong correlation between the sources, they have been synthesized into a single data set from 1927 to 2024 based on assumed copper contents (Table 1) and shown in Figure 7.

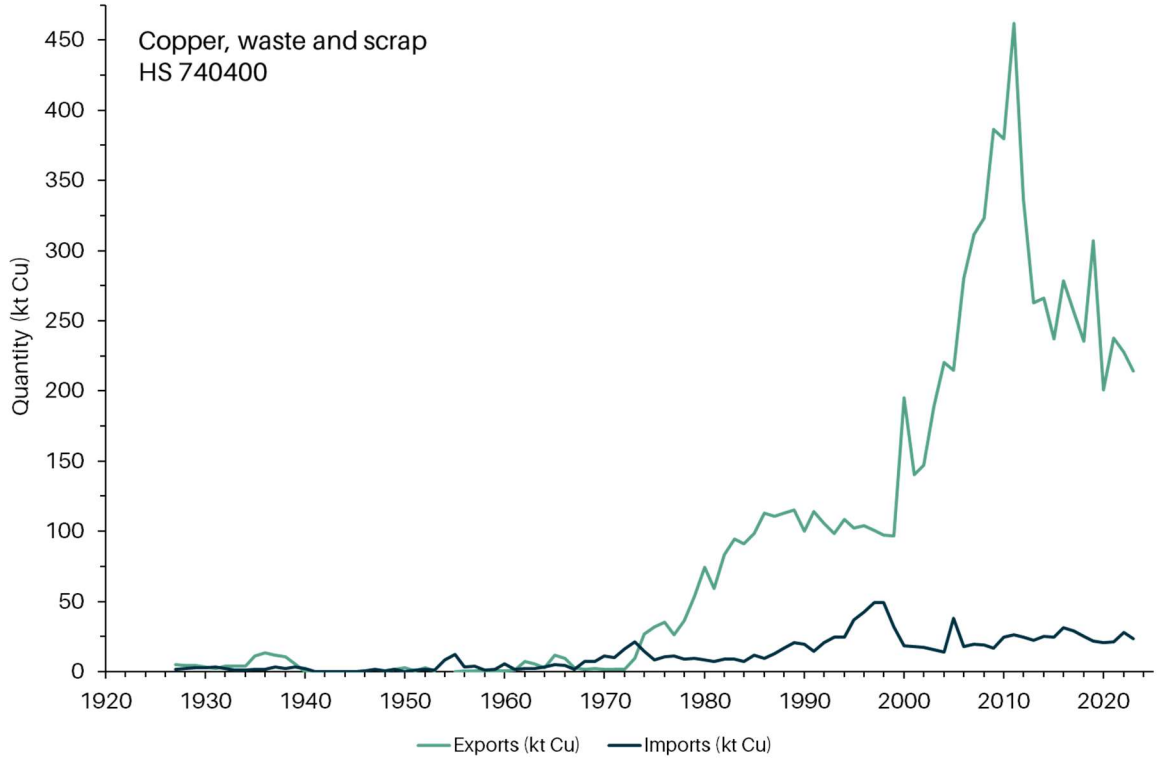

Figure 7 History of imports and exports of copper waste and scrap for the UK (in thousand tonnes (kt) contained copper). Data synthesized from Bide et al. (2024), Idoine et al. (2025), United Nations Department of Economic and Social Affairs (2024), including historical editions. BGS © UKRI 2025.

For data from 2001 to 2024, it is possible to combine UN Comtrade with UK trade information to explore where imports and exports are coming from or going to, respectively, shown in Figure 8. Europe has been the dominant source for copper waste and scrap imports, being around 80 per cent for most of this period, whilst all other regions and China are relatively minor. For exports, however, it can be seen that China evolves from about 20 per cent in the early 2000s (averaging 52 892 tonnes), about 58 per cent over 2009 to 2012 (the period of peak exports, averaging 252 181 tonnes) then gradually declining to 21 per cent in 2020 (47 396 tonnes) but increasing to 43 per cent by 2024 (99 027 tonnes). Europe has been important for exports, typically between 20 to 55 per cent of total exports.

The average annual imports and exports of copper waste and scrap by major world region and China for the most recent period of 2020 to 2024 are given in Table 6. For imports, Ireland is 51.1 per cent (averaging 13 758 tonnes per year), followed by the Netherlands at 21.8 per cent (averaging 5 870 tonnes per year). For exports, China is 29.0 per cent (averaging 72 891 tonnes per year), followed by India at 13.8 per cent (averaging 34 728 tonnes per year) and then Germany at 10.3 per cent (averaging 25 974 tonnes per year).

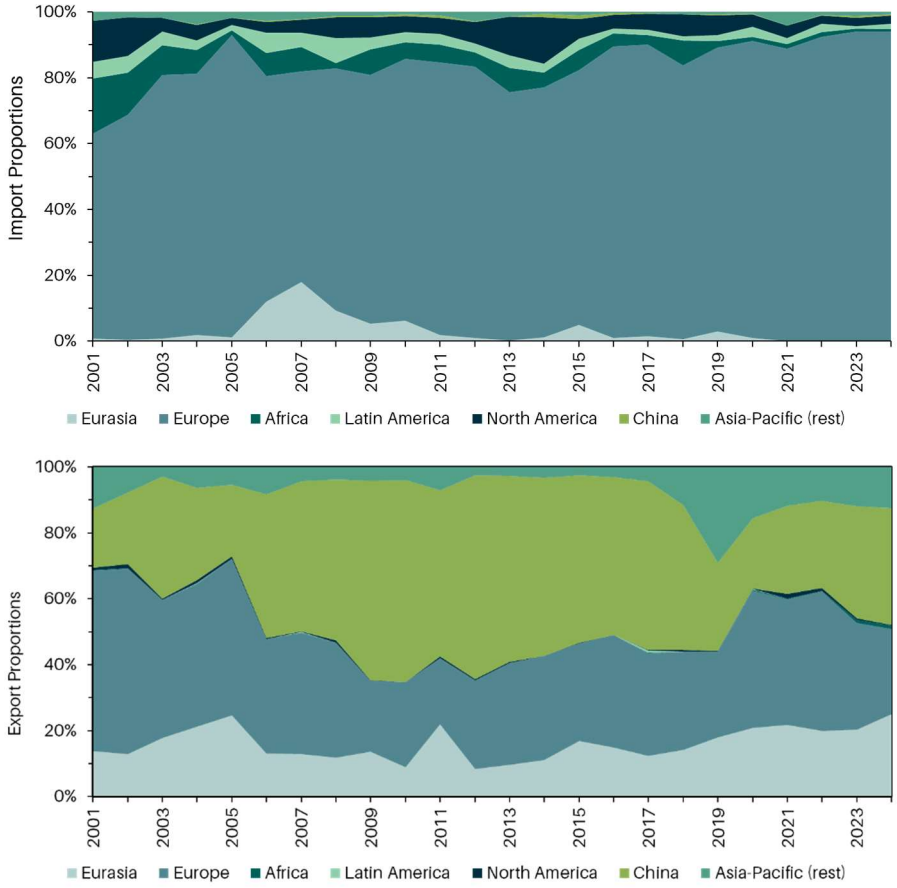

Figure 8 Principal regions for imports and exports of copper waste and scrap to and from the UK, respectively, 2001 to 2024 (shown as proportions). Data synthesised from UN Comtrade (United Nations Statistics Division, 2025) and UK trade information (HM Revenue & Customs, 2025a). BGS © UKRI 2025.

Table 6 Average annual quantities by principal world regions and China for imports and exports of copper waste and scrap to and from the UK, respectively, for 2020 to 2024. Data synthesised from UN Comtrade (United Nations Statistics Division, 2025) and UK trade information (HM Revenue & Customs, 2025a).

Imports by region or country	Quantity (tonnes per year)	Exports by region or country	Quantity (tonnes per year)
Europe	24 620	Europe	89 985
North America	804	China	72 891
Latin America	529	Eurasia	54 413
Asia-Pacific (excluding China)	397	Asia-Pacific (excluding China)	31 021
Africa	313	North America	1 611
China	82	Africa	1 287
Eurasia	79	Latin America	100
Total	**26 824**	**Total**	**251 308**

Bide et al. (2024) and Idoine et al. (2025) (plus historical editions) also report data back to 1927 across the principal stages of the copper supply chain, with the following broad groupings (allowing for changes in reporting over time and equivalent forms):

- ores: assumes 20 per cent Cu content 1920 to 1940 and 25 per cent Cu thereafter, based on BGS expert knowledge of global copper mining and historical copper ore grades
- concentrates: assumes 20 per cent Cu content, based on BGS expert knowledge of global copper mining and historical data for copper concentrates
- mattes: assumes 60 per cent Cu content (Table 1)
- cements, precipitates and scale: assumes 60 per cent Cu content (Table 1)
- unwrought unrefined copper: assumes 99.5 per cent Cu content (Table 1)
- unwrought and wrought refined copper: given the figure of over 99.95 per cent Cu for refined copper, no copper content is applied
- unwrought and wrought copper alloys
    - brass and bronze alloys: 84.1 per cent Cu content (based on data from International Wrought Copper Council (2025))
    - master alloys: assumes 60 per cent Cu content, based on typical range of 30 to 90 per cent Cu
- chemical forms and residues
    - copper sulfate: 39.8 per cent Cu content based on stoichiometric calculation (the fraction of copper in $CuSO_4$; assumes a pure crystal form with no hydration)
    - ash and residues: assumes 25 per cent Cu content, based on BGS expert knowledge of global copper sector
- copper waste and scrap: assumes 90 per cent Cu content, based on BGS expert knowledge of global copper sector (further analyses of this are presented later)

These data were collated with results in Figure 9. In general, the UK remained a major net importer of copper throughout the 1900s, primarily as unwrought refined copper. In 2000, imports declined rapidly and were minimal by 2007. Exports were typically minor in comparison from 1920 until the 1970s, albeit across various forms. From 1974 exports became dominated by copper waste and scrap, with exports of copper waste and scrap always exceeding imports to 2024.

From 2004 the UK has been a net exporter of copper based on copper content as presented in Figure 9. Section 4.1.5 discusses this evolution over time. Totals by form are given in Table 7.

A few important observations are evident from Figure 9 and Table 7:

- the overall balance of copper flows between 1920 and 2023 are imports (at 16 329.3 kt Cu), especially refined and unrefined copper
- copper waste and scrap flows are strongly towards exports, with net exports being the norm since 1974
- the situation or balance of flows can change relatively quickly. For example, in 1997 imports totalled 420 763 tonnes Cu whilst exports totalled 136 233 tonnes Cu, a net import of 284 530 tonnes Cu; a decade later this had changed to 79 738 tonnes Cu imports and 335 028 tonnes Cu exports, a net export of 255 290 tonnes Cu.

Although copper waste and scrap exports have been trending downwards in the past decade, it is unclear whether this will continue or whether there will be a new plateau or even reversal to being a net importer based on evolving copper-supply needs in the UK. These needs may include, for example, the energy transition and rollout of EVs and associated charging infrastructure, or growing renewable energy generation and electrical grid needs.

It must be noted that the data syntheses and analyses presented in this report are not comprehensive MFAs. Rather, they provide an important view of imports and exports of copper in its principal forms, especially as this relates to understanding the scale of copper waste and scrap flows.

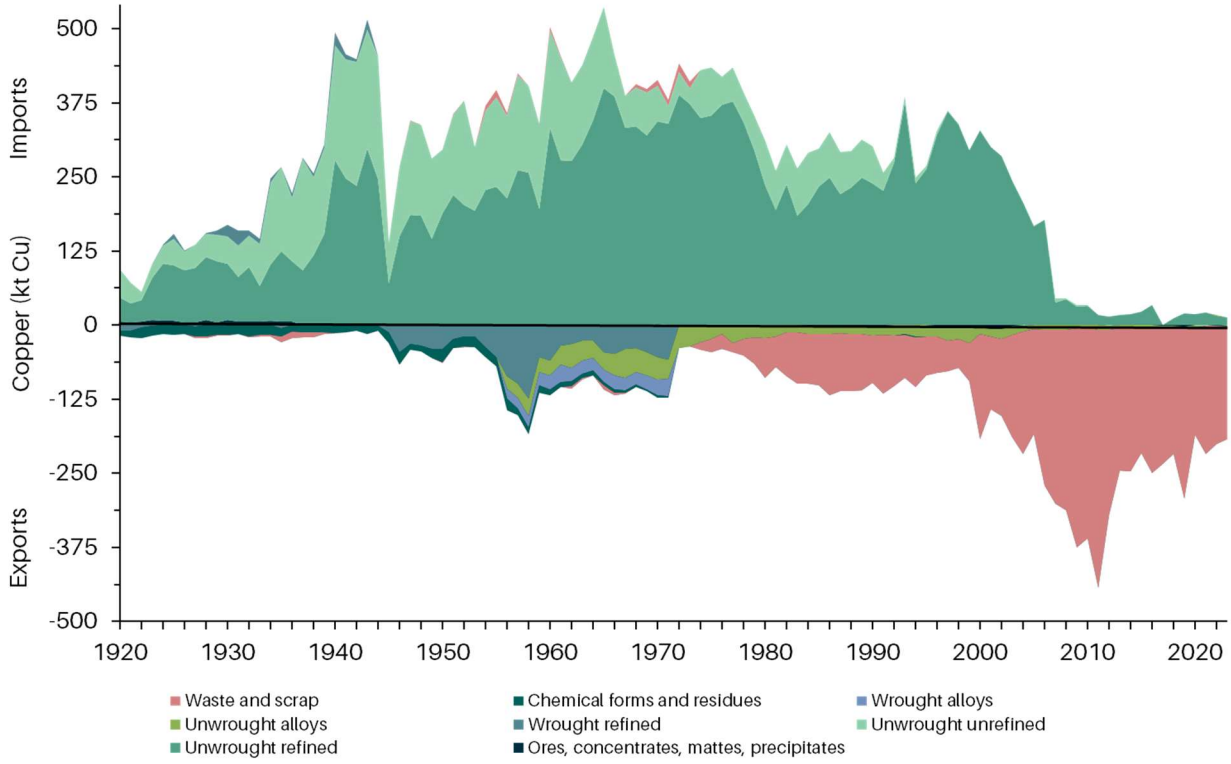

Figure 9 Copper content from 1920 to 2023 for UK imports (positive) and exports (negative) by the principal forms of copper (in thousand tonnes (kt) contained copper). Data synthesised from Bide et al. (2024), Idoine et al. (2025) and United Nations Statistics Division (2025) (including historical editions). BGS © UKRI 2025.

Table 7 Totals by copper content for the principal copper forms in UK imports and exports between 1920 and 2023 (thousand tonnes Cu) (data from Figure 9).

Principal copper form	Imports	Exports	Net flow[A]
Ores, concentrates, mattes, precipitates, scale	134.6	79.5	55.1
Unwrought refined	21 940.6	1 865.2	20 075.4
Unwrought unrefined	7 028.3	16.9	7 011.4
Wrought refined	708.7	1 812.3	-1 103.6
Unwrought alloys	163.8	1 382.6	-1 218.8
Wrought alloys	0	364.9	-364.9
Chemical forms and residues	3.8	679.4	-675.6
Waste and scrap	1 204.0	8 653.8	-7 449.8
Totals	**31 183.7**	**14 854.4**	**16 329.3**

[A]positive value represents net imports, negative value represents net exports.

4.1.3 UK trade information

The UK trade information portal (HM Revenue & Customs, 2025a) provides trade data at higher resolution than UN Comtrade. For copper waste and scrap, three eight-digit CN codes align with the UN Comtrade HS740400 code:

- CN74040010 copper waste and scrap refined
- CN74040091 copper waste and scrap brass
- CN74040099 copper waste and scrap alloys

The proportions of each are shown in Figure 10 for imports and exports, adopting the estimated average copper content values from Table 1. The increase in alloys over time is clear for imports, whilst exports show variations over time. The estimated copper content for imports shows a gradual increase over time, mainly due to the rising proportion of alloys. In contrast, the copper content of exports fluctuates, largely influenced by the varying proportion of alloys. This underscores the need to examine the forms of copper waste and scrap in more detail than is possible using UN Comtrade data alone, highlighting the greater insights available through eight-digit UK trade data.

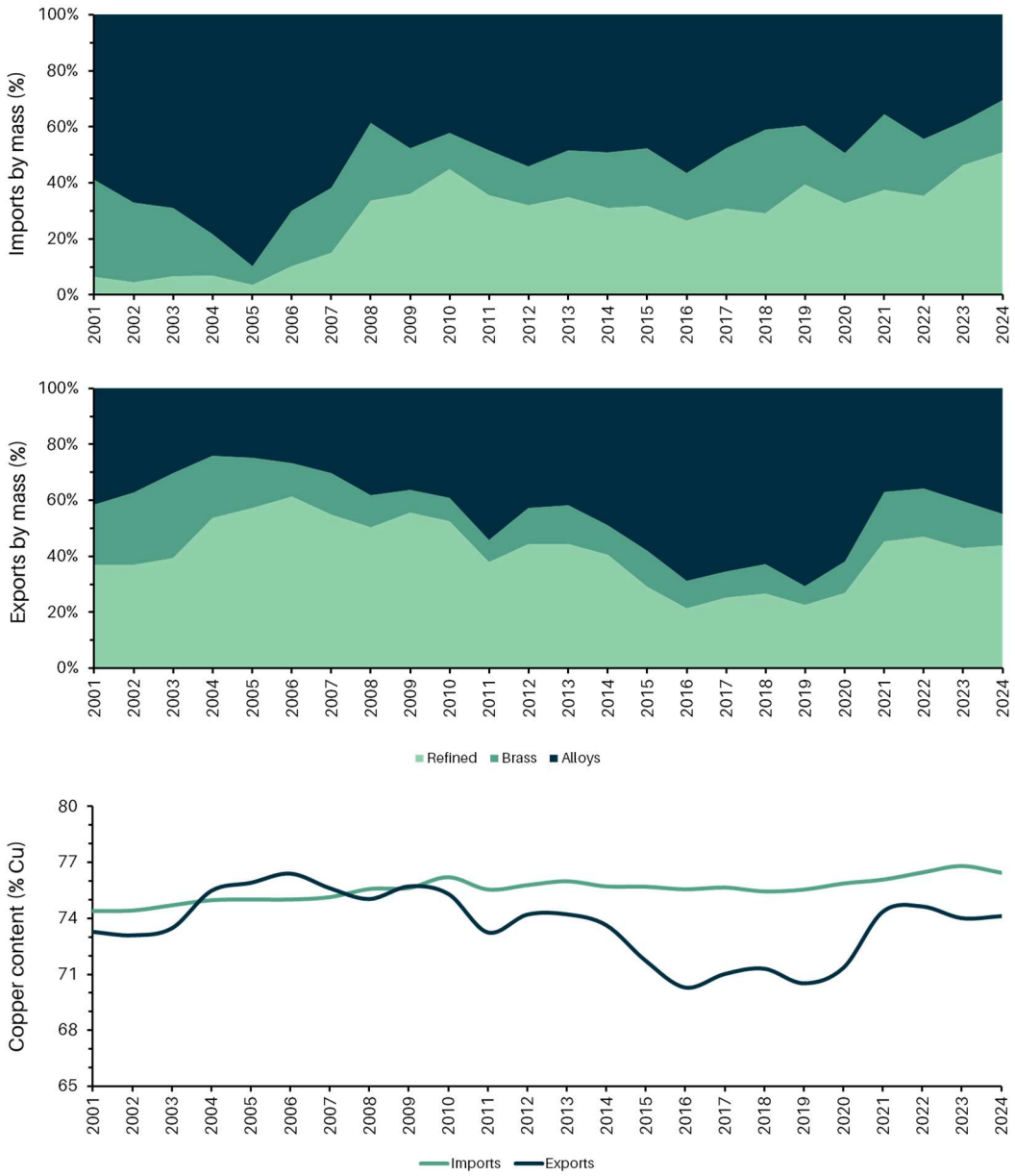

Figure 10 Proportion of refined, brass and alloys in copper waste and scrap exports and imports and estimated average copper content, 2001 to 2024. Data HM Revenue & Customs (2025b) and assuming copper contents from Table 1. BGS © UKRI 2025.

4.1.4 Copper waste statistics

The Environment Agency publishes annual data about waste management in the UK through its Waste Data Interrogator (WDI), providing information about the types and quantities of waste that are handled by waste management facilities (Environment Agency, 2024), including historical editions back to 2006 when the scheme started. Published information includes but is not limited to:

- location of the waste management site
- site operator
- European Waste Catalogue (EWC) codes and descriptions
- type of site (landfill; metal recycling site; etc)
- amount of material

Data are typically reported as either received or removed; the former refers to waste material that is delivered to and accepted by a waste management facility, whereas the latter refers to waste material leaving a waste management facility for further treatment or disposal. For the purpose of this study, only data for waste material removed from metal recycling sites have been considered, as they are likely to provide a more conservative estimate of waste flows.

There are several copper-bearing waste streams represented in the EWC codes. However, some codes are highly aggregated and therefore it is not possible to know with any certainty the actual amount of copper contained in the reported waste flow (for example, non-ferrous metal).

The following EWC code were considered for this study:

- 17.04.01: copper, bronze, brass
- 17.04.10: cables containing oil, coal tar and other dangerous substances
- 17.04.11: cables other than those mentioned in 17.04.10
- 20.01.35: discarded electrical and electronic equipment other than those mentioned in 20.01.21 and 20.01.23 containing hazardous components
- 20.01.36: discarded electrical and electronic equipment other than those mentioned in 20.01.21, 20.01.23 and 20.01.35

Other codes that likely contain copper include categories such as discarded vehicles and batteries.

No attempt has been made to apply metal contents to the EWC codes, as the inherent heterogeneity of these waste streams makes it very challenging to determine an accurate content figure. It should also be noted that material can pass through several waste handling sites before reaching its final destination and may have been subject to several processes (e.g. sorting, separation, shredding, etc). If a material is processed to a point where it meets a set of specific criteria (for example, metal purity), it may be deemed end of waste (EoW). At this point, it is no longer treated as waste, nor is it reported as such. Inconsistencies in reporting can also occur due to changes in the EWC codes over time and how waste is categorised (similar to changes in HS codes over time).

A comparison of the WDI with UN Comtrade data is shown in Figure 11. Plotting tonnes of waste copper, bronze, and brass plus cables produces a pattern that is very similar to that for tonnes of copper waste and scrap exports, although a significant gap still remains (especially noting the WDI data is not adjusted for copper content, which would increase the gap). There also appears to be a timing difference; UN Comtrade spikes in 2019 whilst WDI spikes in 2021, but the extent to which these are related remains unclear. If tonnes of discarded electronic waste are added, the gap between the patterns further reduces.

The gap between tonnes of waste copper, bronze, and brass plus cables (WDI data) versus copper waste and scrap exports (UN Comtrade data) for the period 2006 to 2011 is more significant than for recent years, which may be due to reporting inconsistencies, a missing waste flow (for example, an important EWC code that needs to be included in the analyses), or even possible thefts of copper (Section 4.1.6). With further interrogation of WDI data, especially additional codes, it may be possible to more accurately map exactly what forms of waste copper are being exported.

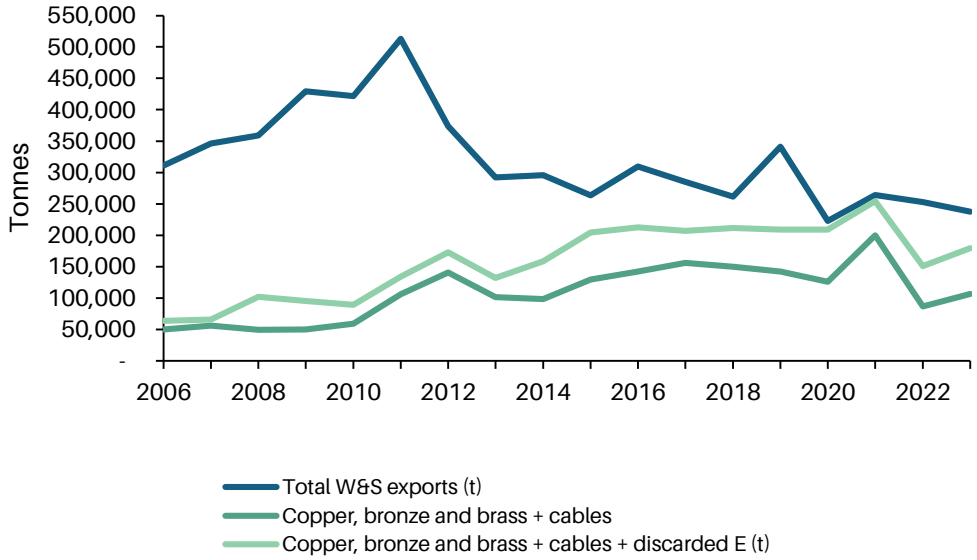

Figure 11 Copper waste and scrap exports (UN Comtrade data from Figure 7) and key copper waste streams from the WDI (copper; bronze; brass; cables and discarded electronics); tonnes as reported (data not adjusted for metal content). Data from Environment Agency (2024), including historical editions. BGS © UKRI 2025.

4.1.5 A brief historical review of global and UK copper refining

The UK has a long history of copper mining, smelting and refining, particularly in Wales and Cornwall. Mining and smelting grew rapidly in the 18th century and continued until the early 20th century, whilst copper refining persisted until the end of the 20th century (Evans and Miskell, 2020; Symons, 2003). The 19th century also saw UK expertise and interests globalise copper mining and smelting, a central element of the Industrial Revolution (Evans and Saunders, 2015). By the mid-1800s, Swansea in particular was a global hub for the smelting of imported copper ores from Australasia, Latin America and southern Africa.

From the 1860s, however, the rise of a large and independent copper sector in the USA, led initially by Michigan then joined by Montana, Arizona and Utah, plus growing production from countries such as Chile and Australia, eventually led to the complete downgrading of Swansea's role by the 1920s.

Perhaps one of the most important technological achievements during the 19th century was the invention of electrolytic copper refining in about 1865 through Elkington's patents (Elkington, 1865, 1869). This led to the world's first commercial electrolytic refinery at Pembrey, South Wales, around 1869 (Gore, 1894; Newell, 1990; Wraith et al., 2018). Electrolytic refining, however, was not widely adopted in the UK; fire refining remained a prominent process because it was cheaper and produced copper of suitable quality for industrial use. However, as demand for high-purity copper grew, particularly for electrical applications, fire-refined copper served an ever-shrinking market (Mackey and Wraith, 2004).

By 1913, the UK smelted and refined barely 5 per cent of the world's copper output, whilst the USA represented more than 55 per cent of mine production and was electrolytically refining more than 90 per cent of the world's crude copper output (Carpenter, 1920). The development of new, large mines in the USA in the late 19th and early 20th centuries resulted in complementary refineries being built. At about this time, there were 10 refineries in the USA with an average individual capacity of approximately 23 000 tonnes per year, more than that of the UK (Mackey and Wraith, 2004). Crucially, the USA obtained much of its production from local ore supplies, whereas the UK now had to rely entirely on imported ores, matte, blister copper and precipitate or cement copper (Carpenter, 1920).

The USA's control extended beyond domestic resources to international deposits, particularly in Chile, allowing American companies to influence global copper prices and attract smelting materials from other countries for treatment. This resource control, combined with domestic ore access, enabled American smelters to pay higher prices for imported copper materials than their British counterparts could afford (Carpenter, 1920).

The development of bessemerising copper mattes[3] in 1880 enabled blister copper to be manufactured at source (Levy, 1912). The subsequent widespread adoption of this method in countries such as the USA eliminated the cost-reducing advantages that had previously made exporting copper regulus[4] to British smelters economically viable (Levy, 1912; Ayres et al., 2003). By 1921, Swansea's smelting capacity had ceased, partly due to competition from American smelters and this shift in global production patterns (Ayres et al., 2003).

The development of smelting and refining capabilities in ore-producing countries further weakened the UK's competitive position (Ayres et al., 2003). Countries that had previously exported raw materials began processing them domestically, reducing the flow of feedstock to British refineries and eliminating the transportation cost advantages that had historically favoured processing in the UK. The closure of Swansea's White Rock Copper Works in 1929 was attributed to cheaper ore smelting elsewhere, particularly in Cornwall (Musgrove, 2011).

The technological gap widened with the development of the 'Isa' process in the 1970s and 1980s in Australia. This method introduced permanent stainless steel cathode plates instead of disposable starter sheets, resulting in lower costs, increased refining intensity, and higher quality copper (Armstrong, 1999). Whilst the Isa process was rapidly adopted worldwide throughout the 1980s in the USA, Canada, Chile, Australia, and Europe, only one UK refinery, Imperial Metal Industries (IMI) Refineries Ltd at the James Bridge Copper Works in Birmingham, England, adopted this method in 1992 (Armstrong, 1999).

The development of solvent extraction-electrowinning (SX-EW) technology from 1968 onwards represented an additional advancement in global copper production. First implemented at Ranchers Bluebird, Arizona, USA, in 1968, SX-EW offered several advantages. It could process low-grade ores without smelting, reducing energy costs over smelting and making smaller-scale operations economically viable (Armstrong, 1999). By 1998, SX-EW accounted for 18 per cent of global copper output, compared to just 6.4 per cent in 1990 (Ayres et al., 2003). This technology may have hindered UK operations, which relied heavily on imported materials and lacked access to domestic ore deposits that could benefit from SX-EW processing.

A critical distinction in understanding the UK's decline is the difference between primary and secondary copper processing. With ore production and imports virtually absent by the early 20th century, UK operations increasingly relied on secondary feedstocks such as scrap copper and waste materials. Secondary copper refining was dominant in the UK, with operations like the James Bridge Copper Works (which by 1974 was the UK's largest scrap refinery; The National Archives, n.d.-WMC), becoming increasingly important as primary smelting and refining of primary material declined. However, even this sector faced challenges from international competition. The advancement of copper refining techniques also broadened the gap between UK and international refining, with more competition possibly playing a role in the closure of multiple sites including the Hafod-Morfa sites in Swansea, Enfield Rolling Mills in London and BICC's refineries during this period (Armstrong, 1999).

The UK's reliance on imported materials also created cost disadvantages. Transportation costs for importing ores, matte, and blister copper added to operational expenses, whilst competitors

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[3] Molten copper matte containing chalcocite (Cu_2S) and pyrite (FeS) is poured into a refractory-line Bessemer converter. Hot air is blown through tuyeres at the base of the converter, initiating oxidation. The pyrite eventually forms iron silicates ($FeSiO_3$; slag) and chalcocite forms cuprous oxide (Cu_2O) to form molten copper and emits sulphur dioxide (SO_2) to produce blister copper (98 per cent Cu). This blister copper is then further purified by electrolytic refining (to 99.95 per cent Cu).

[4] Copper regulus is an impure smelting product that is mostly copper but with some other metals too (it is an older term no longer in common use).

with domestic ore supplies avoided these costs entirely (Carpenter, 1920). The economic pressures intensified during the 1970s and 80s as the Isa process and SX-EW technology reduced global production costs (Armstrong, 1999). Only one or two UK companies could afford to operate smelting works economically (Carpenter, 1920), highlighting the industry's financial constraints. The advancement of SX-EW technology may have affected the closure of the James Bridge Copper Works in 1999 along with competition from international markets (Ayres et al., 2003).

Some of the key historical copper refineries in the UK are described in Appendix 4, noting this is a brief review only and not intended to be comprehensive. The list shows the varying locations, scales and feedstocks of copper refining facilities in the UK historically. This is important since they also correspond to key inflection points in the imports and exports of copper forms into the UK (Figure 9). For example, the closure of the James Bridge Copper Works in Birmingham in 1999, which processed mostly secondary copper and was the last copper refinery operated in the UK, is the point at which copper waste and scrap exports rise rapidly. The history of UK copper refineries with respect to imports and exports is annotated in Figure 12. Historical data for copper refining in the UK from 1963 to 1999, when the last refinery closed, is presented in Figure 13 with key events from this period annotated. Both figures illustrate how historical events affected the industry.

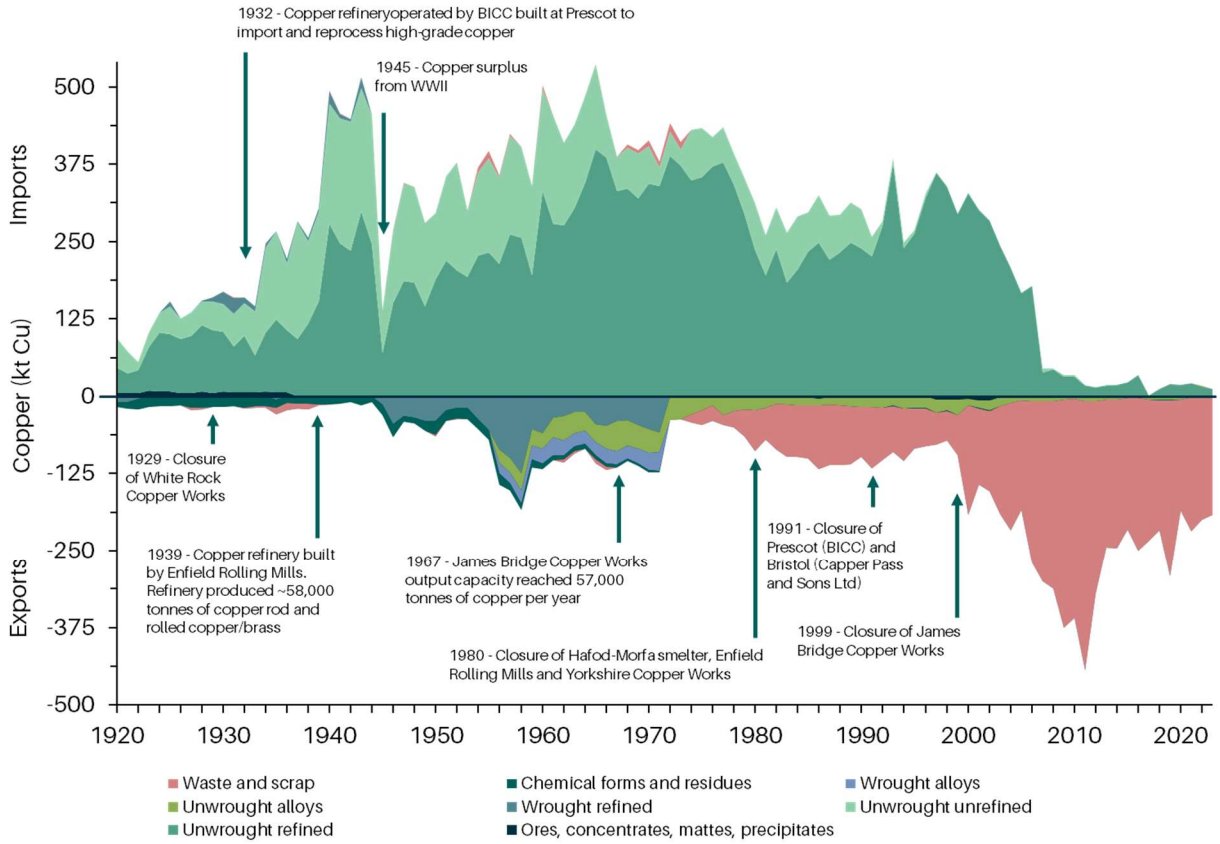

Figure 12 UK imports (positive) and exports (negative) by the principal forms of copper (from Figure 9) annotated with key UK copper refineries opening and closing (in thousand tonnes (kt) Cu). BGS © UKRI 2025.

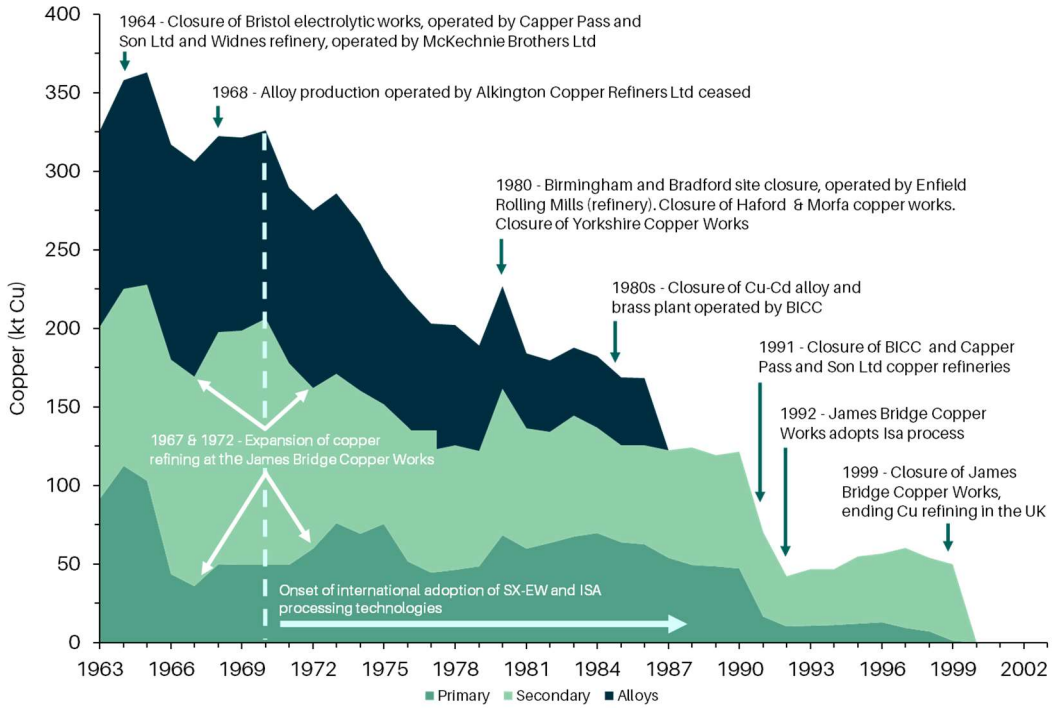

Figure 13 Historical copper refining in the UK for alloys and primary and secondary refined copper from 1963 to 1999, annotated with key historical events (in thousand tonnes (kt) Cu). Data from Bide et al. (2024) (including historical editions). BGS © UKRI 2025.

4.1.6 Other factors that could affect copper waste and scrap exports

In addition to data reporting inconsistencies and missing waste flows, there are other factors or issues that could affect the collection and export of copper waste and scrap. It is not possible, however, to quantify the contribution of such factors to the export volumes observed in trade data. Some factors that could be relevant are summarised.

4.1.6.1 THEFT

A study by Sidebottom et al. (2014) supports the theory that copper theft correlates with copper prices. With copper prices reaching £6 200 per tonne in 2011, January 2011 saw approximately double the rail cable theft compared to January 2010 (Sturdey, 2011). Gas suppliers, electricity companies and telecom cables were also targeted, with the company E.ON reporting 850 incidents of copper theft in 2010, approximately 50 incidents per month, which was double the number seen in 2009 (Sturdey, 2011). This rise in copper theft resulting from elevated copper prices may partly explain the rapidly increasing export of copper waste and scrap around 2010 and 2011.

Typically, copper waste and scrap were sold to recycling yards in England and Wales that paid in cash, potentially facilitating the unidentifiable sale of stolen materials. However, by December 2012, cash payments became illegal and cashless payment systems such as cheques or electronic transfers were required (Home Office, 2012). This regulatory change effectively made it difficult to sell stolen goods, possibly contributing to the fall in copper waste and scrap exports observed from 2012 onwards.

4.1.6.2 FIBRE OPTIC CABLES

In 2008, fibre optic cables began to be used to provide broadband telecommunications services, replacing older copper wires. In 2024, BT Group Plc recovered or recycled 1,750 tonnes of old or EoL telecommunications equipment and 5,600 tonnes Cu cables (BT Group Plc, 2025). BT Group has also recently negotiated a deal with recycling company EMR to support the

extraction and recycling of 200 000 tonnes of Cu cable from their network until 2028, with 3 300 tonnes extracted by March 2024 (Croft, 2024). There appears to be no clear evidence during the replacement process that copper cables were extensively recovered until recently, suggesting that this was most likely not a major source of copper waste and scrap around the time of the 2011 peak in exports (Figure 7).

4.1.6.3 PRICE

The general market price for refined copper displays a correlation with exported copper waste and scrap (Figure 14). The price of copper and copper waste and scrap exports in the UK between 2000 and 2020 showed a coefficient of correlation (R^2) of 0.61, suggesting a reasonable link between the two variables. However, from 2021 onwards, the price of copper considerably increased but the total export of copper scrap gradually decreased. The correlation between 2000 to 2025 is weaker with an R^2 of 0.31, suggesting that, whilst copper prices influenced the amount of copper scrap exports, other factors became increasingly influential after 2020.

Figure 14 Copper price compared with copper waste and scrap exports. Data: copper waste and scrap, see Figure 7; copper prices are from London Metals Exchange through INSEE (2025). BGS © UKRI 2025.

4.1.6.4 CHINA

The UK primarily exports copper waste and scrap (HS740400) to China, with the total exports to the world forming a strong positive correlation with total export to China with an R^2 of 0.80 (data from HM Revenue & Customs, 2025a). Since 2002, China has been the world's largest copper consumer, met by both primary and secondary copper, with the main source of secondary copper being imported scrap (Dong et al., 2020).

In 2013, China implemented the ‘Green Fence’ policy to restrict the import of copper waste and scrap globally. This policy, combined with other policy changes by the Chinese government (2007, 2012 and especially after 2017) led to a drop in the volume of exported copper scrap from major exporting countries such as the UK to China (Dong et al., 2020; Liu et al., 2021).

The increasingly stringent policies led to the total amount of copper waste and scrap imported by China dropping sharply from 4.51 million tonnes in 2012 to 1.35 million tonnes in 2019 (Liu et al., 2021). Additionally, a ban on all solid waste imports came into effect in 2021 except for copper products that meet the recycled copper standards (Liu et al., 2021). Secondary copper is becoming increasingly supplied by domestic scrap and is expected to be the main source of secondary production (Dong et al., 2020).

The strong positive correlation between UK exports of copper waste and scrap under code HS740400 and China's import of UK copper waste and scrap, alongside policy changes in China reducing the total volume of copper waste and scrap from 2012 onwards, may be strong contributors to the peak in UK exports of copper waste and scrap in 2011 and the decline thereafter.

4.1.7 Synthesis

Overall, the data collated and synthesised for this study suggest that there are substantial quantities of copper being exported from the UK in the form of waste and scrap, leading to the situation of consistent net exports of contained copper since 2004. In terms of understanding these flows within a circular economy framework, they are shown in a Sankey diagram against the key stages of raw material extraction, intermediate processing and downstream uses in Figure 15, based on data from Figure 9 and Table 7. It must be remembered that the analyses are not a comprehensive MFA, as many products that contain copper have not been included. Internally flows in the UK have not been assessed either; only import/export trade data.

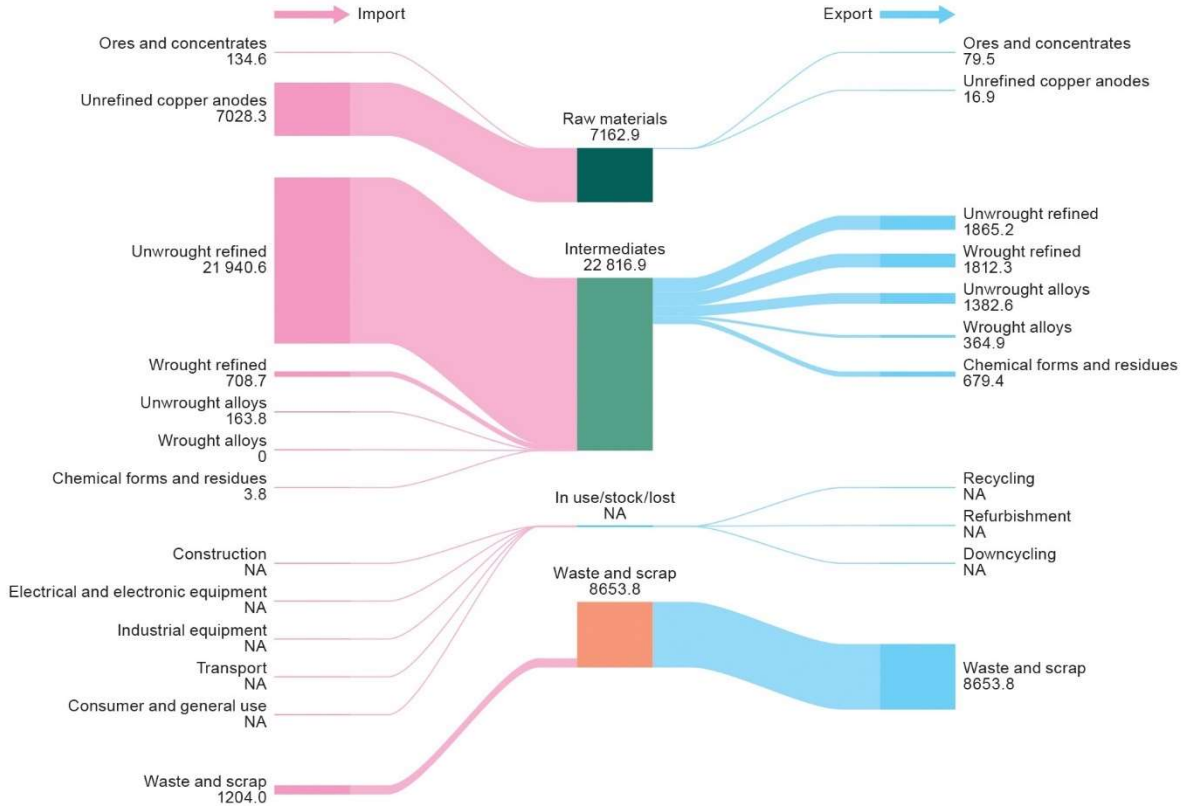

Figure 15 A Sankey diagram of cumulative assessed copper trade flows to and from the UK economy between 2000 and 2024 by principal supply chain stages (in thousand tonnes of contained copper; NA – not assessed). Note this does not include in-use stocks and flows inside the UK. Created by BGS based on data synthesis in Figure 9 and given in Table 7.

Given that the UK was a very minor copper producer over the period 1920 to 2024 (about 12000 tonnes Cu (Bide et al. (2024); Idoine et al. (2025)), including historical editions), the analyses suggest that the UK economy established a large inventory or stock of copper in the 20th century (imports of 31 183.7 kt Cu; Table 7) but this has been drawn down by exports mostly in the form of copper waste and scrap (14 854.4 kt Cu; Table 7), reducing UK stocks by 16 329.3 kt Cu (noting this is not a complete MFA).

There is a gradual declining trend for copper waste and scrap exports (Figure 7; Figure 9), but it remains unclear how long this will continue, especially given the dynamics of the global copper sector and various factors that can encourage or discourage exports, such as copper prices, international trade policy, changing transport technologies and the energy transition.

Overall, this suggests that there is a strong case for improving the circularity of copper use in the UK by re-establishing secondary copper refining, such as that at the former James Bridge works in Birmingham. At present, the only company proposing such a facility is Evolve Metals Ltd but, given the scale of copper waste and scrap exports, there is certainly scope for more companies and projects to capture that flow. For example, the past five years have seen an average of 200 000 tonnes Cu contained in copper waste and scrap exports that, at the average 2024 market price of US$9 259 per tonne of copper (United States Geological Survey, 2025) and an exchange rate of US$1.00 to £0.782[5] for a UK price of £7 244 per tonne of copper, gives an approximate value of £1.45 billion per year.

Based on UN Comtrade data, the average stated value of copper waste and scrap exports over the past five years is US$1.44 billion per year or about £1.06 billion per year. These values are indicative only and not intended to be a financial analysis. They do, however, highlight that the value gap of £0.41 billion per year is substantial and presents an opportunity for the UK to capture that value by improving the circularity of copper in the UK.

4.2 TUNGSTEN

Tungsten remains a crucial metal throughout the UK economy. This is highlighted by significant economic activity and value associated with various Prodcom codes, as well as consistent imports and exports of tungsten and tungsten-containing products (Table 2). However, considerable tungsten uses remain difficult to discern in available data due to aggregation within various ferroalloy codes and numerous products containing small quantities of tungsten.

4.2.1 UK Prodcom

Although a Prodcom code exists for tungsten ores and concentrates (07291920), it is not present in the Prodcom dataset, even during the period from 2015 to 2018 when the Drakelands (now Hemerdon) mine was operated by Wolf Minerals Ltd and produced tungsten ores and concentrates (Bide et al., 2019). Based on data from Bide et al. (2024), including historical editions, the Drakelands mine produced 3 728 tonnes W in concentrates from 2015 to 2018. For comparison, the current mineral resource estimate for Hemerdon contains an estimated 314.4 kt W and 76.4 kt Sn plus an additional 4.6 kt W and 0.6 kt Sn in tailings (AMC Consultants (UK), 2025).

Other Prodcom codes often lack reported data or the data is suppressed to protect the commercial sensitivity of a small number of operators (for example, codes 20121981, 20136430, 27401250, 27401293 and 27401295). Prodcom code 24453013, however, contains data for 2019 to 2023, shown in Table 8.

Table 8 Prodcom data for code 24453013, tungsten (wolfram) and articles thereof. Data from Office for National Statistics (2025a). ([e]estimated data)

	2019	2020	2021	2022	2023
Value (£)	58 414 000	5 857 000	5 063 000	5 886 000	8 885 000
Quantity (tonnes)	7 367	20 193[e]	17 393	20 945[e]	30 424[e]
Price (£/tonne)	7 929	290	291	281	292

[5] Office of National Statistics: https://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/timeseries/auss/mret

At first glance, it might seem that values for 2019 are substantially different to those from 2020 to 2023. For example, the magnitude in value changes from £58.4 million in 2019 to £5.86 million in 2020 and the quantity similarly changes from around 7 400 tonnes to about 22 200 tonnes, respectively, leading to a 27-fold reduction in unit prices. The Office for National Statistics confirmed this data was reported correctly based on data provided by companies actively reporting manufacturing against this code (Office for National Statistics, 2025b). This code is described as 'Tungsten (wolfram) and articles thereof', with the category including CN codes:

- 81011000: tungsten powders
- 81019400: unwrought tungsten obtained by sintering
- 81019600: tungsten wire
- 81019910: tungsten not obtained by sintering
- 81019990: articles of tungsten not elsewhere specified.

These are all relatively pure or high tungsten-content forms.

Over the period 2019 to 2023, world tungsten mine production averaged 94 100 tonnes W, meaning that the UK's average production of 22 200 tonnes W (Office for National Statistics, 2025a) would represent the equivalent of some 24 per cent of world mine production but without any operating mines. According to the Office for National Statistics (2025b), a major business and facility closed in 2019 and there were significant increases in product volumes but decreases in values (substantially lower unit prices), leading to the changes observed in Table 8. This is discussed further in Section 4.2.5.

4.2.2 UN Comtrade

The code for tungsten waste and scrap in UN Comtrade is 810197. Import and export data are only available from 2002 to 2024 and are shown in Figure 16. Although there is a minor excess of exports over imports (particularly since 2007), this is relatively modest, especially compared to the significant excess observed in copper (Figure 7).

Figure 16 History of imports and exports of tungsten waste and scrap for the UK (quantity only, not adjusted for tungsten content). Data from United Nations Statistics Division (2025). BGS © UKRI 2025.

UN Comtrade HS282590 code describes material traded as calcium, beryllium, tin, mercury, cadmium, tungsten and other or not elsewhere specified inorganic base and metal oxides, hydroxides, and peroxides. Using UK trade information for CN28259040, which is specific to tungsten oxides and hydroxides, an estimated proportion of tungsten oxides and hydroxides can be calculated from the UN Comtrade data for HS282590.

The analysis presented in this report focuses on UN Comtrade data from 2000 to 2024, specifically the following forms (HS codes and tungsten contents given in Table 2):

- ores and concentrates at 55 per cent W
- tungstates and wolframates at 70.2 per cent W for APT and 72.2 per cent W for AMT
- tungsten oxides and hydroxides at 76 per cent W
- tungsten carbides at 93.9 per cent W
- ferrotungsten and ferrosilicotungsten at 77 per cent W
- tungsten halogen filament lamps for vehicles at 0.07 per cent W
- tungsten halogen filament lamps for >100 V at 0.06 per cent W
- tungsten halogen filament lamps for <100 V at 0.01 per cent W
- tungsten powders at 100 per cent W
- tungsten bars, rods, other forms obtained by sintering at 100 per cent W
- tungsten bars, rods, other forms not obtained by sintering at 100 per cent W
    - bars, rods at 94 per cent W content
    - articles not elsewhere specified at 90 per cent W content
- tungsten wire at 100 per cent W
- tungsten not elsewhere specified at 94 per cent W
- tungsten waste and scrap at 60 per cent W

The results, given as contained tungsten, are shown in Figure 17 for UK import and export quantities and Figure 18 for net trade flows.

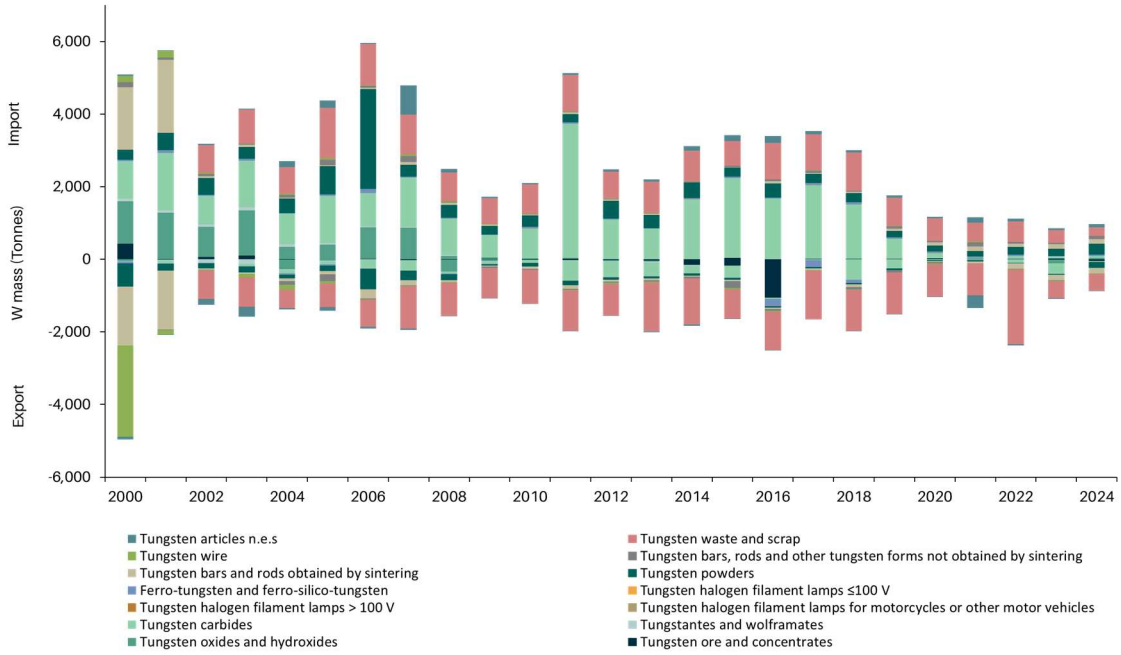

Figure 17 UK trade flow of tungsten embedded in various tungsten forms and products, including products the UK imports (positive) and exports (negative) (tonnes W). Created by BGS based on data from United Nations Statistics Division (2025). BGS © UKRI 2025.

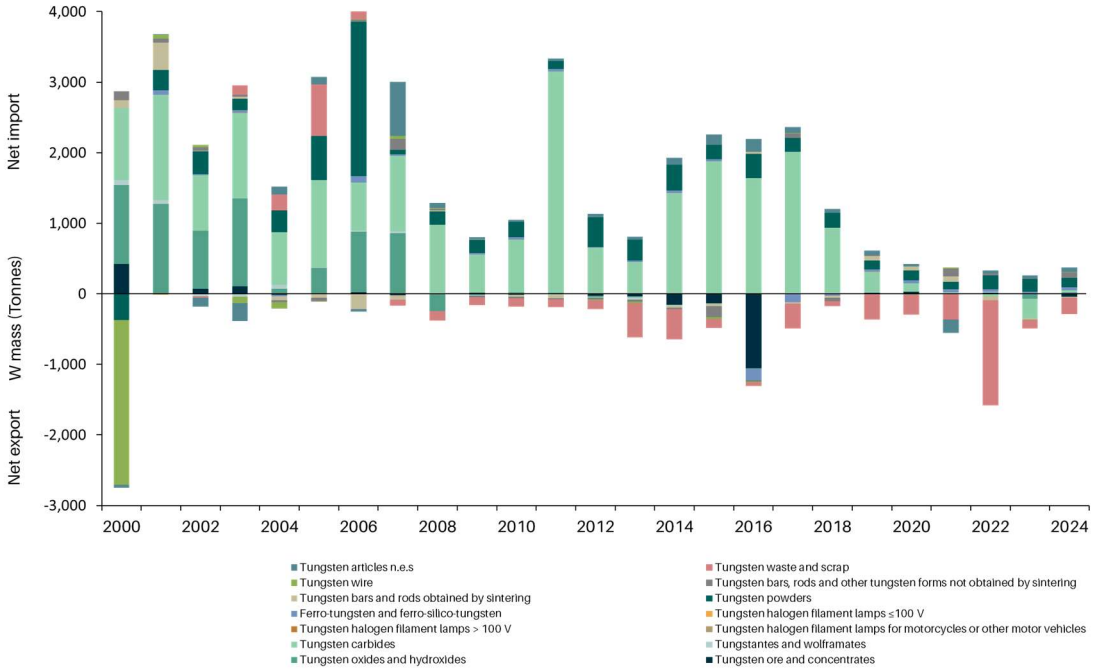

Figure 18 UK net trade flow of tungsten embedded in various tungsten forms and products, including products the UK net imports (positive) or net exports (negative) (tonnes W). Created by BGS based on data from United Nations Statistics Division (2025). BGS © UKRI 2025.

According to UN Comtrade data, the UK was a net importer of tungsten products between 2000 and 2020 and in 2024 and a net exporter of tungsten products between 2021 and 2023. The magnitude of UK net imports has deceased over time, mainly net imports of:

- 2000 to 4000 tonnes of total W metal between 2000 and 2007
- 1000 to 3000 tonnes of total W metal between 2008 and 2018
- less than 1000 tonnes W metal from 2019 onwards

The magnitude of net exports of tungsten products from the UK is typically much smaller than net imports and is usually less than 600 tonnes. Exceptions are:

- 2000: 2 800 tonnes
- 2016: 1 300 tonnes
- 2022: 1 600 tonnes

Although significant quantities of tungsten halogen filament lamps are traded into and out of the UK, applying the tungsten content of the lamps reduces the significance of the quantity of the traded product. This is due to the very small percentage of tungsten in lamps (Table 2).

Between 2000 and 2007, the net import mixture of tungsten products mainly consisted of tungsten oxides and carbides, with smaller amounts of tungsten powders (except 2006), tungsten waste and scrap, other tungsten articles and other forms. Within the same period, the net export mixture varied annually, with a large tungsten wire export in 2000 (about 2300 tonnes) and minor net exports of various tungsten products (less than 400 tonnes per year).

The 2008 economic recession is likely to have been the main driver for the decrease in trade in tungsten products between 2008 and 2010; another economic crisis has been credited with the decrease of traded tungsten products between 2012 and 2013 in European and American markets (Tang et al., 2023). Between 2008 and 2020, the net import mixture mainly consisted of tungsten carbides and powders, with lesser quantities of other tungsten articles. The net export mixture between 2007 and 2020 mainly consisted of tungsten waste and scrap in varying quantities, alongside lesser quantities of other tungsten products.

Between 2014 and 2016, the net export mixture of tungsten products changed, presumably due to tungsten concentrates being produced and exported from the Drakelands (Hemerdon) mine, then owned by Wolf Minerals Ltd. Although Wolf Minerals continued production of tungsten concentrates until October 2018, that is not fully reflected in UN Comtrade export data. For HS261100, the average exports from 2004 to 2013 are 26.8 tonnes per year (imports averaged 12.8 tonnes per year), rising to 279.4 tonnes in 2014, 316.3 tonnes in 2015 and 1 927.5 tonnes in 2016. There is no data reported after that until 2023 and 2024, with 12.4 and 88.7 tonnes, respectively.

According to Bide et al. (2024), UK tungsten production (in tonnes W), all from the Drakelands (Hemerdon) mine, was:

- 2015: 195
- 2016: 923
- 2017: 1 370
- 2018: 1 240

The total production for 2015 and 2016 was 1 118 tonnes W, equating to about 2 030 tonnes of W concentrates, which is very close to Comtrade data for these years of 2 243 tonnes (gross weight). Given the pattern of small quantities of imports and exports for most years prior to 2014, this suggests that the UK was acting as a trading hub, albeit on a very small scale in global terms. It is likely the tungsten concentrates produced at the Drakelands (Hemerdon) mine between 2017 to 2018 were either misreported under another trade code or potentially consumed domestically, which seems unlikely given the lack of concentrate processing facilities in the UK. Small net exports of ferro-tungsten are reported for 2016 and 2017.

From 2020 onwards, the UK's net imports of tungsten products averaged approximately 400 tonnes, comprising mainly tungsten powders, with smaller quantities of tungsten metal forms not obtained by sintering, and other tungsten products. During this same period, UK net export quantities were typically up to 600 tonnes, except for 2022 (1 600 tonnes), mainly comprising tungsten waste and scrap, but some years also included tungsten carbide (2023), tungsten articles not elsewhere described (2021) and minor amounts of other tungsten products.

The results derived from UN Comtrade have required expert judgment to present realistic UK tungsten trade. For instance, in 2006, UN Comtrade HS261100 (tungsten ores and concentrates) recorded an import from the world market to the UK of 4 941 369 kg (4 941 tonnes). This value was identified to be erroneous, since no other value in the UN Comtrade data series for HS261100 has a similar magnitude. Investigation revealed that 4 907 tonnes of this material was reportedly exported by Germany to the UK.

For Germany to export this volume, it would need to have significant production of tungsten concentrate or have stockpiled tungsten concentrates. Given no German tungsten deposits were in production for this year or years prior, and the fact that Germany would need to have stockpiled the previous five plus years of tungsten ores and concentrates without producing midstream products from them, it was decided to correct this point using alternative trade data. This example highlights the need to query apparent anomalies in trade data when modelling mineral supply chains either nationally or globally.

4.2.3 UK trade information

Based on UK trade information data (HM Revenue & Customs, 2025b) and metal contents for the various tungsten codes and forms (Table 2; Section 4.2.2), the UK's total imports and exports by quantity of tungsten content in selected tungsten containing commodities, including the raw materials, intermediates, semi-manufactured, and waste and scraps are shown in Figure 19.

There has been a sustained, albeit modest, increasing trend in exports alongside a decreasing trend in imports over the last 25 years, particularly since 2018. Since 2021, the volume of total exports has surpassed the total imports of tungsten in the selected forms. Of particular importance is the fact that the data are consistent with UN Comtrade data (comparing Figure 17

and Figure 19). Furthermore, imports are typically between 1 000 to 3 000 tonnes W per year (averaging 2,500 tonnes W per year) and exports are typically between 500 and 2 000 tonnes W per year (averaging 1 400 tonnes W per year) (noting some years are lower or higher). These ranges and averages compare to the average of 22 200 tonnes (gross weight) per year between 2020 to 2023 based on Prodcom data for code 24453013 (Table 8). In general, most forms vary only slightly over the years, although carbides decline from 2018 and do not recover.

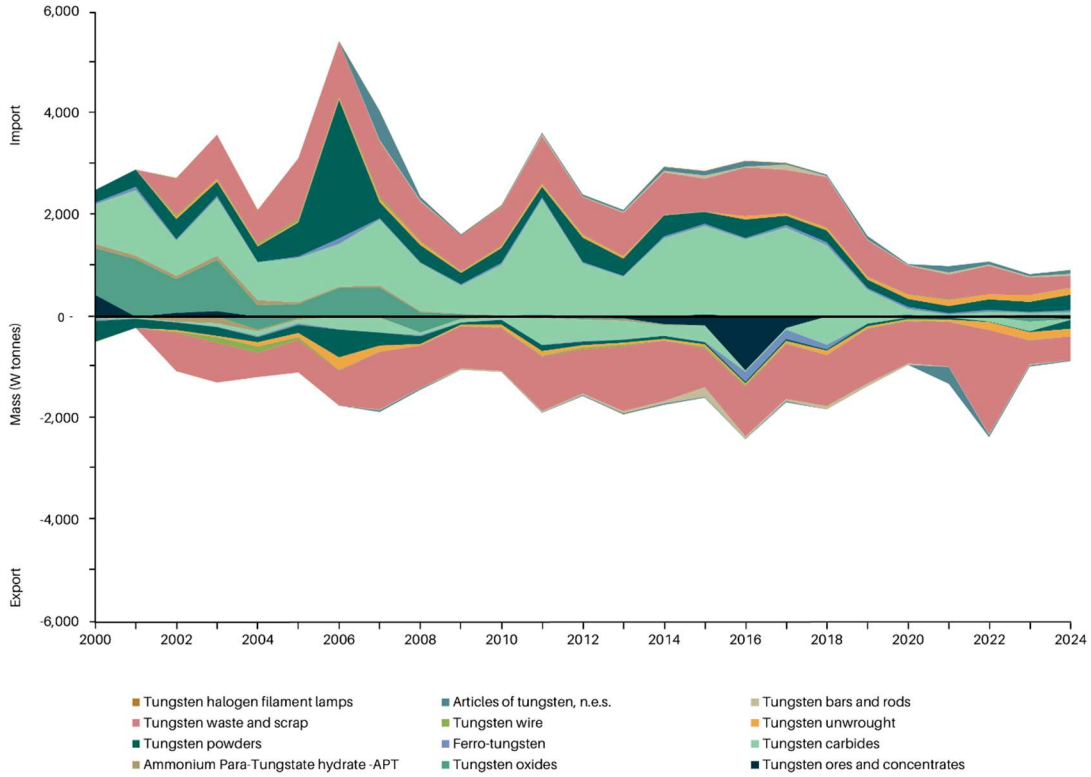

Figure 19 UK trade flow of tungsten metal embedded in the commodities (tonnes W). Data from HM Revenue & Customs (2025a). Note: CN code: 26110000, described as tungsten ores and concentrates, has an erroneous import mass value for the year 2005 and has been amended based on the investigation with other international trade reports. BGS © UKRI 2025.

The cumulative totals of imports and exports for all principal tungsten forms are given in Table 9. The data show that the two most dominant forms are carbides (37.2 per cent of imports; 11.0 per cent of exports) and waste and scrap (28.4 per cent of imports; 59.6 per cent of exports). Over the 25 years of cumulative data (2000 to 2024), total imports are 61 687.6 tonnes W compared to total exports of 35 181.0 tonnes W, highlighting the overall result of net imports of 26 506.6 tonnes W.

Based on UK trade information data (HM Revenue & Customs, 2025a), the UK was a net exporter of tungsten ores and concentrates during the period of 2000 to 2024 (Table 9). The Drakelands (Hemerdon) mine produced 3 728 tonnes W in concentrates from late August 2015 to October 2018, which would equate to about 6 780 tonnes concentrate, but this is not all captured in UK trade export data, nor are any data reported in Prodcom (Section 4.2.1).

This appears at odds with the expectation that all production was to be exported to the USA and Austria (Wolf Minerals Ltd, 2015). As observed with respect to UN Comtrade data for exports of tungsten ores and concentrates (Section 4.2.2), the same confusion is repeated in UK trade information data, although exports of 417.5 tonnes are reported for 2017. This consistent discrepancy between Prodcom, UN Comtrade, UK trade information and known mine production and expected export quantities remains puzzling.

Table 9 Totals by tungsten content for the principal tungsten forms in UK imports and exports between 2001 and 2024 (tonnes W). (Data from Figure 19)

Principal copper form	Imports	Exports	Net flow[A]
Ores and concentrates	800.0	1 824.8	-1 024.8
Oxides	5 500.6	881.0	4 619.6
Ammonium paratungstate (APT)	575.6	388.3	187.3
Tungsten carbides	22 927.6	3 876.5	19 051.1
Ferrotungsten	906.9	667.4	239.5
Powders	9 721.6	3 008.5	6 713.1
Unwrought	1 266.2	1 677.3	-411.1
Wires	369.0	545.7	-176.6
Bars and rods	554.6	710.8	-156.2
Tungsten halogen filament lamps	61.4	13.3	48.1
Miscellaneous	1 464.2	614.9	849.3
Waste and scrap	17 540.0	20 972.3	-3 432.3
Totals	**61 687.7**	**35 180.8**	**26 506.9**

[A]positive value represents net imports, negative value represents net exports.

Imports of tungsten ores and concentrates to the UK reflect the use of it in non-refinery purposes, such as to produce ferrotungsten and other materials which require ores and concentrates as primary feedstock. Ferrotungsten is often made by smelting tungsten concentrates with iron elements in an electric arc furnace (Tungsten Metal Group, 2025).

For the various intedmediate stages, the UK has no current capacity to process tungsten ores and concentrates into tungsten-based forms or products. There are processing facilities in Germany and Austria (International Tungsten Industry Association, 2025b), with Austria being one of the export destinations for concentrates from the Drakelands mine previously and planned for the current restart of Hemerdon.

Most of the UK's tungsten intermediates demand, which primarily includes ammonium paratungstate (APT), ammonium metatungstate (AMT), tungsten oxides (trioxide, blue oxide and yellow oxide), powders, chemicals and carbide, is supplemented by imports. In the supply chain, which details a multistage flow of tungsten, the intermediate stage of materials is the key to UK industries. These industries are heavily reliant on imports that mostly come from a few countries with concentrated production capability, such as China. The ADS Group, a UK trade association advancing leadership in aerospace, defence, security and space, reports that the UK has several tungsten member companies that have leading innovations and capabilities to value-add from imported tungsten intermediates and export them to high-end manufacturing (ADS, 2025).

The UK's total export of the intermediates during the period of 2000 to 2024 has been reflected in trade statistics (Figure 19). However, it should be noted that a majority of the net import (total value of imported goods exceeds its total value of exported goods over a specific period) of tungsten intermediates are consumed as feedstock for domestic semi-manufacturing for tungsten products, including tungsten wire, bars, cutting and drilling components, and lamps. These products would be used in the automotive, aerospace, mining and other industrial sectors.

4.2.3.1 DOWNSTREAMS

Globally, the recycling rate for tungsten, including both production scrap and EoL products, is around 30 per cent, whilst the recycling rate of tungsten carbide products is about 46 per cent (Zeiler et al., 2021). In Europe, about 42 per cent of tungsten waste and scraps are recycled and reused (SCRREEN, 2023). It is reasonable to expect that, given similar industrial sectors, infrastructure and technologies, the UK would also have a notable secondary supply of tungsten. However, estimating the tungsten recycling capacity in the UK is challenging given the complexity in reporting, lack of publicly available data and contribution of closed-loop recycling, which is widely adopted in the alloying industry where a significant amount of tungsten is utilised (International Tungsten Industry Association, 2025b).

It has been reported, however, that a significant amount of tungsten waste and scrap was exported from 2000 to 2025. This could be primarily due to a combination of factors, including:

- higher prices offered overseas
- limited domestic recycling capacity (no recovery of pure metal from EoL products)
- existing regulations that may make it cheaper to export than process domestically

This provides a significant opportunity for the UK to invest in domestic recycling capabilities, especially in recycling processing technologies, including pyrometallurgy (high-temperature smelting), hydrometallurgy (using solvents), and electrochemical refining. Secondary supply or recycling of tungsten (and other critical metals) is crucial for resource conservation, energy savings and reducing environmental burden, as well as reducing the exposure of the industry to market volatility and high raw material costs caused by current geopolitics (Energy News, 2015; Graedel and Allenby, 2010).

4.2.4 Tungsten waste statistics

The Environment Agency WDI was reviewed for possible tungsten waste and scrap flows (Environment Agency (2024) and earlier editions). However, data for tungsten waste and scrap flows in the UK, although captured by various EWC codes, are too aggregated to be useful for meaningful assessment (for example, ‘non-ferrous metal’). Therefore, no analysis of WDI waste data for tungsten has been undertaken.

4.2.5 Synthesis

Overall, the data collated and synthesised for this study suggest that there are significant flows of tungsten into and out of the UK economy, although unlike copper, tungsten waste and scrap imports and exports are almost equal and other forms of tungsten flows show net imports. In terms of understanding these flows within a circular economy framework, they are shown in a Sankey diagram against the key stages of raw material extraction, intermediate processing and downstream uses in Figure 20, based on data from Figure 19.

It must be remembered that the analyses are not a comprehensive MFA, as many products that contain tungsten have not been included. Internal flows in the UK have not been assessed; only import-export trade data. Given that the UK was a very minor tungsten producer over the period 1920 to 2024 (about 6 kt W (Bide et al., 2024; Idoine et al., 2025) including historical editions), the analyses suggest that the UK economy is a net consumer of tungsten but it is not possible to estimate stocks without considerable further research.

Finally, the magnitude of tungsten trade flows in Figure 20 are worth comparing to the Prodcom values. According to Prodcom, code 24453013 averages about 22.2 kt annually from 2020 to 2023 (Table 8), which is supposed to be relatively high content tungsten forms. However, data in Figure 20 suggest that cumulative flows over 2000 to 2024 were imports of 37.3 kt W (an average of 1.5 kt W per year) and exports of 11.1 kt W (an average of 0.44 kt W per year), leading to a net import of 26.2 kt W at an average of 1 kt W per year. These values are substantially lower than the Prodcom data, with the only realistic interpretation being that the Prodcom data must represent products containing a small fraction of tungsten (for example, aerospace components using tungsten alloys).

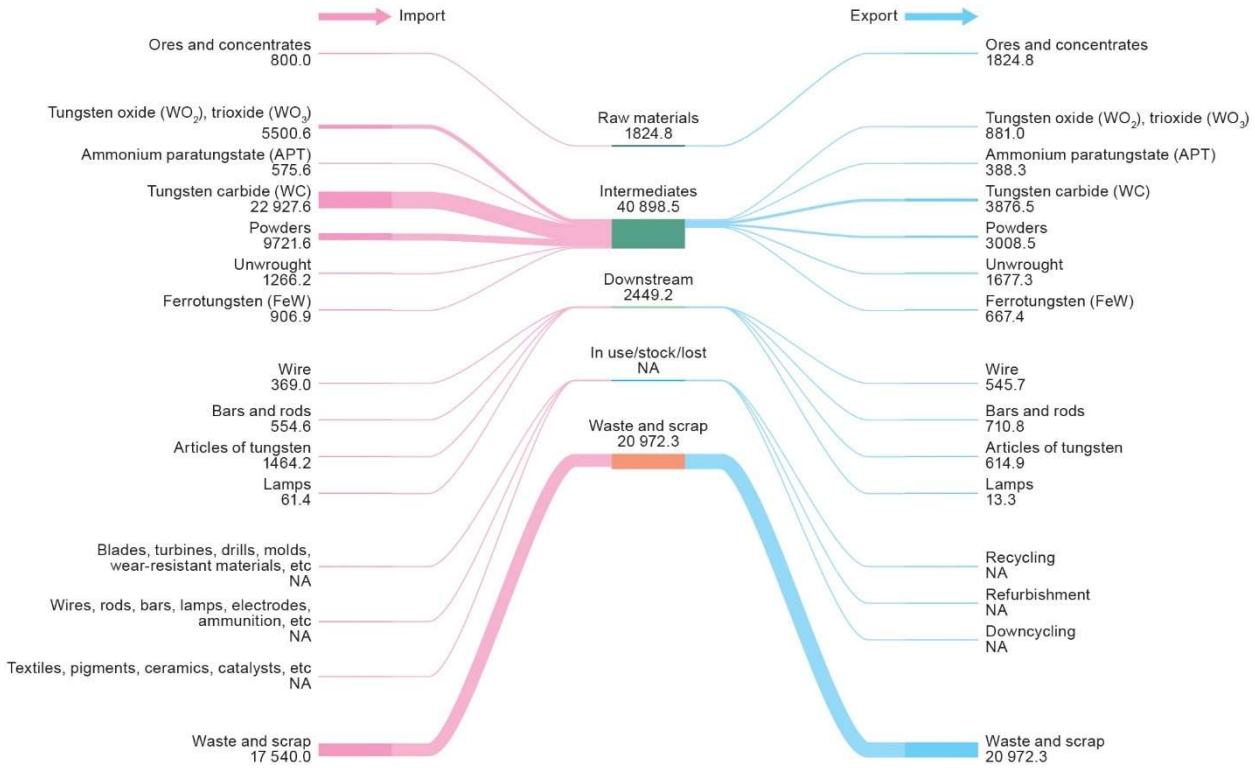

Figure 20 A Sankey diagram of cumulative assessed tungsten trade flows to and from the UK economy between 2000 and 2024 by principal supply chain stages (in tonnes of contained tungsten; NA – not assessed). Note this does not include in-use stocks and flows inside the UK. Created by BGS based on data from HM Revenue & Customs (2025b). BGS © UKRI 2025.

4.3 MONITORING METAL PRICE DYNAMICS

A variety of sources can be used to monitor market dynamics over time, such as:

- commercial: for example, Argus Metals or London Metals Exchange
- government: for example, United States Geological Survey (USGS), German Mineral Resources Agency (DERA)
- open access: for example, derived prices from UN Comtrade and UK trade information

Commercial price data are formatted to include not only information on the commodity trade, but also the valuation of a material's price, including:

- cost of goods, insurance and freight (CIF) or free-on-board (FOB, including the cost of the goods and freight costs to the final destination)
- regional market value (for example Asia, US, Europe)
- status of the goods once sold, such as 'prompt' (delivered within 30 days) or 'delivered' (the price of goods and delivery costs)
- whether the market price is time stamped (for example, for immediate or future delivery).

In UK trade information, imports are valued as CIF but exclude any duty or tax chargeable in the UK. Exports are valued as FOB from the final point of dispatch from the UK (HM Revenue & Customs, 2025a). The value of all goods that flow in and out of the UK are recorded excluding VAT and all other taxes such as duties and levies applied to goods after arrival into the UK (HM Revenue & Customs, 2025c). This data is collated alongside other data sources into the UN Comtrade database (United Nations Statistics Division, 2025). Therefore, the value of UK imports (CIF) and UK exports (FOB) contained in both UN Comtrade and UK trade information excludes VAT, other taxes, duties and levies.

The USGS unit value is reported as the price in US dollars of 1 tonne of either refined copper or tungsten metal apparent consumption (United States Geological Survey, 2020, 2019). For copper, this is estimated as the 'Annual average United States producer copper price' reported in the USGS Minerals Yearbook (United States Geological Survey, 2020) and other USGS report series. For tungsten, this is sourced from annual average price data in the USGS Minerals Yearbook (United States Geological Survey, 2019).

The derived unit price (value divided by contained metal), either from UN Comtrade or UK trade information databases, should not be taken as the unit price for the traded material only; it includes the transportation costs if the original data was valued as FOB and for insurance of the goods in transit if the original data was valuated as CIF. Comparison between these unit values from trade databases and other sources must consider what the price data represents. Price data availability can be limited and qualitative comparisons may have to be used between different valuation methods, market regions and other factors for price data (CIF, FOB, etc). A comparison of UN Comtrade and UK trade information with annual metal prices for copper are shown in Figure 21 and Figure 22, respectively, with tungsten shown in Figure 23.

USGS's apparent consumption unit price values for copper and tungsten strongly correlate with the yearly averages of Argus Metal's 'LME copper cash official price (daily frequency)' and Argus Metal's 'Tungsten 99.9 per cent scrap solids consumer price FOB US…', respectively. For tungsten waste and scrap, USGS's apparent consumption unit price values and yearly averages of Argus Metal's 'Tungsten 99.9 per cent scrap solids consumer price FOB US…' also have a strong correlation with UN Comtrade and UK trade information derived export and import unit price values. In the absence of available price data, this suggests derived export and import unit price values for tungsten waste and scrap can be used as a proxy for market dynamics.

For copper waste and scrap price data, there is no relationship between USGS's apparent consumption unit price value and the derived UN Comtrade and UK trade information export and import unit prices. The derived export and import unit prices are all less than US$1.5 per kilogram of copper. Between 2000 and 2003, the price of refined copper metal (USGS apparent consumption copper unit price) was marginally more than the derived unit price values. Since 2003, the disparity between the derived unit prices of copper scrap and the price of refined copper metal has increased. Depending on market dynamics and the feasibility of operating a secondary copper processing facility that produces refined copper, these differences in unit price could be commercially exploited.

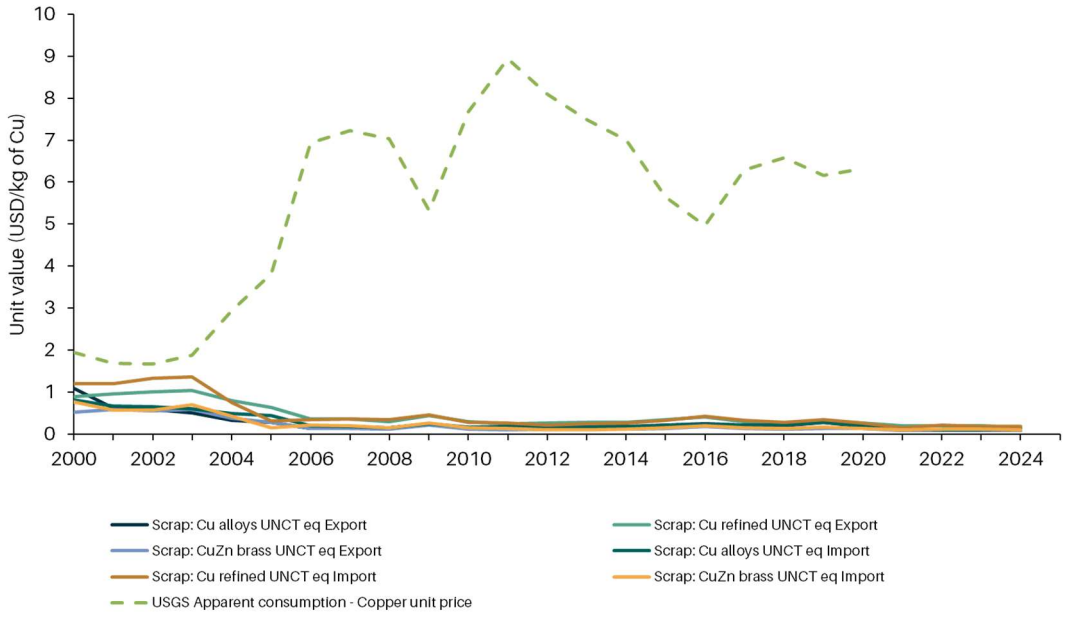

Figure 21 Calculated prices based on UN Comtrade (United Nations Statistics Division, 2025) for copper waste and scrap imports and exports (USD per kilogram Cu) compared to the annual refined copper metal price (United States Geological Survey, 2020). Further price data available

from commercial sources such as Argus Metals is not plotted here due to data usage restrictions. BGS © UKRI 2025.

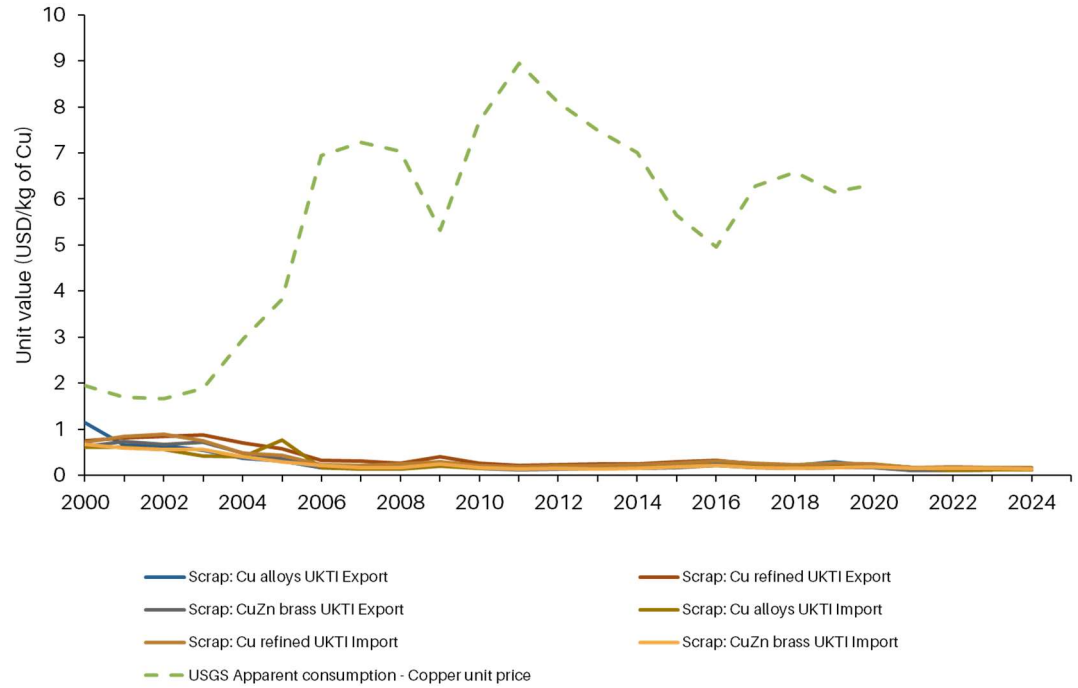

Figure 22 Calculated prices based on UK trade information (HM Revenue & Customs, 2025a) for copper waste and scrap imports and exports (USD per kilogram Cu) compared to the annual refined copper metal price (United States Geological Survey, 2020). Further price data available from commercial sources such as Argus Metals is not plotted here due to data usage restrictions. BGS © UKRI 2025.

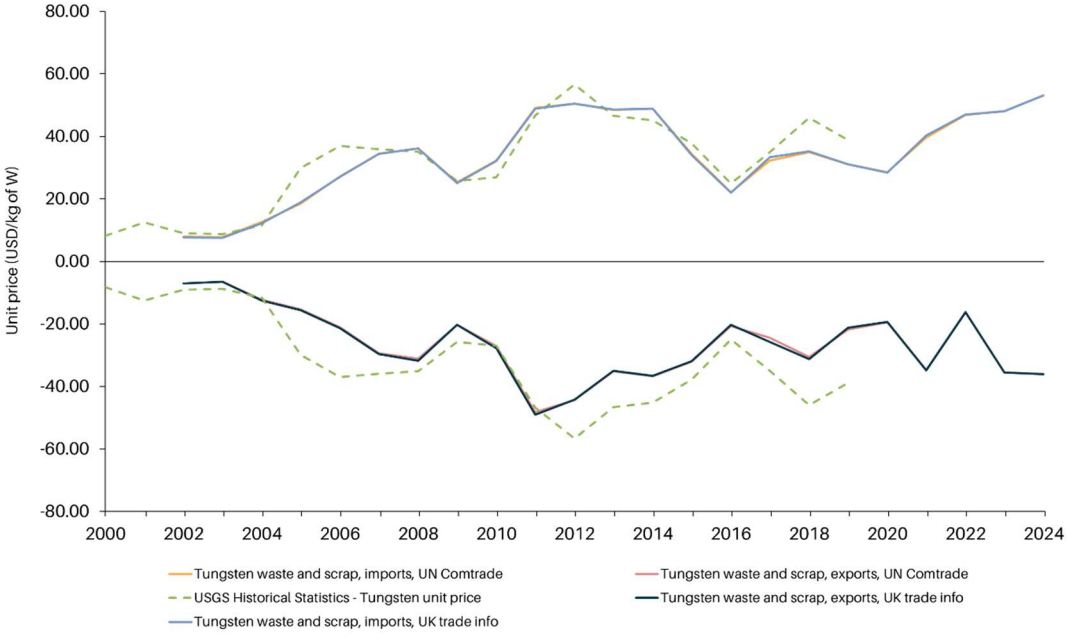

Figure 23 Calculated prices based on UN Comtrade (United Nations Statistics Division, 2025) and UK trade information (HM Revenue & Customs, 2025a) for tungsten waste and scrap imports and exports (USD per kilogram Cu) compared to the annual refined tungsten metal price (United States Geological Survey, 2019). Further price data available from commercial

sources such as Argus Metals is not plotted here due to data usage restrictions. BGS © UKRI 2025.

5 Key findings and opportunities

This study investigated the flows of copper and tungsten waste and scrap through the UK economy, with a particular focus on exploring available economic and trade data to understand opportunities for greater recycling or circularity. The approach adopted was a detailed analysis of all relevant sources of data relating to UK imports, exports and economic activity (noting this was not a complete MFA). The synthesised time series allowed insights into the principal forms for copper and tungsten flows into and out of the UK, especially as they relate to waste and scrap flows.

5.1 KEY FINDINGS: COPPER

- The UK has been a major exporter of copper waste and scrap since 1973, with the amounts growing to a peak of 462 055 tonnes Cu in 2011, declining gradually to average of about 255 000 tonnes Cu in the years since
- Historically, China was the dominant market for UK copper and waste scrap exports, though over 2020 to 2024 Europe has now taken the lead followed by China, Eurasia and the rest of the Asia-Pacific
- From 1920 to 2023, the total contained copper in imports was about 31.2 million tonnes and about 16.3 million tonnes in exports; making the UK a net importer over the past century
- Based on metal contents, the net flow of copper changed in 2004 when the UK became a net exporter of copper
- Key changes in imports and exports over time can be related to the changes in industrial infrastructure and businesses that used to be involved in the copper sector, especially the role of secondary copper refineries – for example, copper waste and scrap exports surged after the closure of the secondary copper refinery in Birmingham in 1999
- Other factors may also be influential on copper waste and scrap exports, such as high prices, possible thefts, China's policies on imports of waste materials, etc
- Current exports of copper waste and scrap are valued at £1.06 billion yet the contained copper is worth £1.42 billion. This means that the UK is not capturing the value that the secondary copper resource represents, providing a major opportunity to improve the circularity of copper in the UK
- The complexity and miniaturisation of modern products are complicating recycling, meaning that manufacturers and recyclers must implement a 'design for recycling' collaboration to enable more effective recycling of copper products.

5.2 KEY FINDINGS: TUNGSTEN

- The UK has been a minor importer and exporter of tungsten waste and scrap, although such data is only available from 2002, with exports slightly exceeding imports on a contained tungsten basis
- Tungsten flows within imports and exports are typically modest in annual quantities, ranging from 100 to 1000 tonnes W per year, but support key manufacturing businesses in the UK
- Current economic and trade data do not accurately capture all tungsten flows, mainly due to the use of tungsten in ferrous and non-ferrous alloys or as minor components in different products or technologies, which leads to uncertainty when using or interpreting this data
- Despite the Drakelands (Hemerdon) tungsten-tin mine operating from August 2015 to October 2018, available economic and trade data only seem to capture such activity for 2015 and 2016, with no obvious reasons for these data gaps
- There are UK companies who recycle of specialty alloys which include tungsten, but the scale appears to be modest relative to tungsten demands and flows

- At present, tungsten remains crucial to the UK economy but opportunities for improving circularity requires considerable further investigation, noting that this would require extensive stakeholder consultation and engagement (with special recognition of the commercial and technological sensitivities involved).

5.3 KEY FINDINGS: OVERALL

- It is not currently possible to use existing data to accurately assess and quantify the extent of circularity of copper and tungsten flows and use in the UK economy; this requires comprehensive material flow analyses to be undertaken as well as extensive data on metal contents across all trade codes and technological uses
- It is crucially important to link resource flows and uses to industrial infrastructure and economic activity; the case of copper in particular shows that, when such infrastructure is lacking, it leads to inefficient resource use through net exports of contained copper in forms such as waste and scrap
- China's role as a consumer continues to influence global trade patterns (as observed in copper waste and scrap flows or tungsten use on a regional basis)
- Future research should:
  - extend the analyses herein to conduct comprehensive MFAs
  - conduct detailed surveys of industrial capacity, including businesses involved in the various stages of copper and tungsten supply chains (such as reviewing major importing countries and their processing of copper waste and scrap flows)
  - explore and potentially develop new ways to estimate the circularity of resource use in the UK, either through adapting available data or devising new data collection.

Appendix 1 Trade code descriptions

COPPER

Ores

Ore is defined in mining as fresh rock that contains a sufficiently high concentration of a metal or mineral to warrant mining and processing for extraction, in this case copper. Typical ore grades range from 0.1 to 5 per cent Cu globally, averaging about 0.5 per cent Cu (Mudd and Jowitt, 2018a).

Concentrates

A common ore processing method is separating the specific minerals within the ore that contain the metal or mineral of interest. This produces a material rich in that metal, in this case copper, which is known as a concentrate. Typical concentrate grades range from 10 to 50 per cent Cu globally, averaging about 25 per cent Cu (Schlesinger et al., 2011).

Mattes

A copper smelter uses pyrometallurgy to treat concentrates, primarily driving off sulfur and leaving mainly copper and iron sulfides. Mattes typically take the form of black or brown granules or a crude mass, with a dull, metallic look. The majority of matte is not solidified but transferred in molten form to a converting furnace. Most matte does not enter the marketplace (International Copper Study Group, 2021).

Cements

Cement copper, also known as precipitated copper, is typically a fine-grained black powder containing copper oxides and insoluble impurities (copper powder) obtained by precipitation (or cementation). For example, the addition of scrap iron to an aqueous solution created from the leaching of low-grade ores, copper-containing wastes or solutions rich in copper (such as acidic mine drainage) leads to precipitation of the copper and dissolution of the iron. Cement copper is commonly added to the charge that goes to a converting furnace to produce copper matte (International Copper Study Group, 2021).

Sulfates

Copper sulfate is common chemical form of copper widely used in agriculture, electroplating and chemical synthesis. It can be produced from scrap or pure copper.

Oxides and hydroxides

These chemical forms of copper are produced in midstream chemical processing and used in pigments, ceramics, and as catalysts or reagents.

Chloride oxides and hydroxides

Chloride oxides and hydroxides are less common chemical forms of copper used in agriculture (as fungicides) and chemistry and are typically midstream speciality products derived from refined copper.

Slags, ash and residues

These are metallurgical residues and by-products from smelting and refining operations containing significant copper content (may also include slags from converters or furnaces). These materials can be reprocessed to recover copper.

Unrefined

Black copper, blister copper and copper anodes for electrolytic refining are all intermediate products:

- Black copper: impure copper created by smelting oxidised ores or impure scrap. The copper content can vary greatly from about 60 to 85 per cent Cu
- Blister copper: another impure form of copper produced in a converting furnace; impurities such as iron and sulfur (amongst others) are oxidised by passing air through molten copper matte, with the final copper content typically being about 98 per cent Cu (International Copper Study Group, 2021)
- Copper anodes: a form of unrefined copper that is produced from blister copper by reduction with natural gas or wood to remove oxygen and other impurities in an anode furnace (International Copper Study Group, 2021). Copper anodes for electrolytic refining are not equivalent to anodes for electro-copper-plating.

Refined

Refined copper is commonly defined as metal containing at least 99.85 per cent Cu (International Copper Study Group, 2021), with the international benchmark being 99.95 per cent pure copper traded as Grade A cathode copper through the London Metals Exchange. Refined copper can be produced by electrolytic refining, electrolytic extraction, chemical refining or fire refining, or through alloying refined copper.

Refined copper is cast into ingots or ingot-bars for remelting (for example, for alloying) or into wires, bars, slabs, billets and similar forms for rolling, extruding, drawing or forging into plates, sheets, strips, wire, tubes and other semi-fabricates. Ingots are also produced by remelting copper waste and scrap. Electrolytic or electrowon copper is melted to produce other refinery shapes (International Copper Study Group, 2021).

Waste and scrap

Copper waste and scrap can include a wide range of sources and forms, such as (International Copper Study Group, 2021):

- discards, process losses, residues, etc, from copper smelters and refineries
- new scrap from cuttings, stampings, turnings or defects during manufacturing of components and wrought forms (new scrap never enters the consumer market in final products)
- old scrap from used or worn-out components or products — castings; electronic scrap; copper-iron materials; catalysts; cables; pipes, etc.

The metal content of copper waste and scrap can therefore vary quite significantly.

Alloys

Alloys are mixtures of metals designed to achieve particular properties such as corrosion resistance, strength, lightweight, etc. The most common Cu-related alloys are:

- brass (copper-zinc alloy)
- bronze (copper-tin alloy)
- cupro-nickel (copper-nickel alloy)
- master alloys with various metals where copper content can vary between 30 and 90 per cent Cu

Although many other alloys can contain copper, these are usually small in volume in comparison to refined copper, brass, bronze, cupro-nickel and master alloys (International Copper Study Group, 2021).

TUNGSTEN

Ores

Ore is defined in mining as fresh rock which contains a sufficiently high concentration of a metal or mineral to warrant mining and processing for extraction, in this case tungsten. Typical ore grades range from 0.1 to 5 per cent tungsten trioxide globally (Schmidt, 2012; Werner et al., 2014; Wilder and Lederer, 2024; Mudd, 2023a, b).

Concentrates

A common ore processing method is separating the specific minerals within the ore that contain the metal or mineral of interest. This produces a material rich in that metal, in this case tungsten, which is known as a concentrate. Typical concentrate grades contain up to 65 per cent tungsten trioxide (or 51.5 per cent W).

The exact tungsten content varies depending on mineralogy:

- ferberite ($FeWO_4$)
- hübnerite ($MnWO_4$)
- wolframite ($(Fe,Mn)WO_4$), which is an intermediate mineral composition between the end members of ferberite and hübnerite
- scheelite ($CaWO_4$)

Most traded forms under this code will be concentrates of relatively high purity.

Ammonium paratungstate (APT) and ammonium metatungstate (AMT)

APT and AMT are important precursor tungsten salts that are converted from concentrates and used in the production of tungsten metal powders, oxides, acids, carbides and chemicals.

APT, with the chemical formula $[(NH_4)_{10}[H_2W_{12}O_{42}]\cdot 4H_2O]$, is produced from either wolframite and scheelite concentrates or tungsten scrap (containing between 40 and 95 per cent W) (Brown and Pitfield, 2014). Concentrate feeds are pressure leached using alkaline reagents (sodium carbonate for wolframite, sodium hydroxide for scheelite) (Brown and Pitfield, 2014). Tungsten scrap feeds are first oxidised to facilitate dissolution in the alkaline leach process, which is achieved using sodium hydroxide pressure leaching, oxidising alkaline melt or electrolysis (Brown and Pitfield, 2014). The resulting sodium tungstate solution is filtered and subjected to further hydrometallurgical processes with the addition of ammonia and evaporation to produce APT with a chemical purity between 90 and 99 per cent (Brown and Pitfield, 2014).

APT can be converted to AMT $[(NH_4)_6[H_6W_{12}O_{40}].3H_2O]$ through partial thermal decomposition or partial replacement of ammonium ions by hydrogen ions using selective ion exchange and evaporation (International Tungsten Industry Association, 2025a). These refined forms of tungsten are produced at refineries, part of the intermediate stages of the tungsten supply chain (Figure 3).

Based on stoichiometry, APT contains 70.4 per cent W, AMT contains 72.4 per cent W and sodium tungstate contains 62.6 per cent W. Traded tungstates and wolframate salts typically contain (H C Starck Tungsten Powders, 2025):

- AMT – between 91 and 92 per cent tungsten trioxide (72.2 and 73.0 per cent W)
- APT – minimum 85 per cent tungsten trioxide (minimum 67.4 per cent W)
- Sodium tungstate – between 70 and 71.5 per cent tungsten trioxide (55.5 and 56.7 per cent W).

Oxides and hydroxides

Tungsten oxides and hydroxides include tungsten yellow oxide (WO_3) and tungsten blue oxide ($WO_{2.97}$). Yellow tungsten oxide (known as ‘YTO’) is produced from the thermal decomposition of APT under oxidising conditions, whereas blue tungsten oxide (known as ‘BTO’) is thermally decomposed under reducing conditions (International Tungsten Industry Association, 2025a).

These products are produced at the refining or intermediate stage of the tungsten supply chain (Figure 3). Traded tungsten oxides such as YTO and BTO typically contain a minimum 99.7 per cent WO_3 (minimum 79.3 per cent W) (H C Starck Tungsten Powders, 2025).

Ferroalloys

Ferrotungsten and ferro-silico-tungsten are part of the ferro-alloys group of steels, although ferro-tungsten is the most commonly traded. Ferrotungsten is produced from the direct smelting of tungsten concentrates including wolframite and scheelite, as well as artificial scheelite and tungsten scrap (Lassner and Schubert, 1999; Brown and Pitfield, 2014).

Ferrotungsten is mainly produced by using carbothermic or carbothermic-silicothermic production in electric arc furnaces (Lassner and Schubert, 1999). Although metallothermic production can produce ferrotungsten, its processing appeal has been diminished by increased costs of aluminium and silicon powders and the requirement for purer raw materials (Lassner and Schubert, 1999).

The production of ferrotungsten is part of the intermediate stage of the tungsten supply chain. Price data for ferrotungsten is listed with metal purities at 75 per cent W or a minimum of 75 per cent W, however, traded ferrotungsten can vary between 70 and 85 per cent W (Stanford Advanced Materials, 2025; METRACO, 2025; BMI Foundary Services, 2025).

Powders

Tungsten powders are produced by hydrogen reduction of YTO or BTO either in pusher or rotary furnaces (International Tungsten Industry Association, 2025a). These processes can produce average tungsten powder particle sizes between 0.1 and 100 µm; a specific average particle size can be produced by altering the regulated temperature and humidity of these processes (Lassner and Schubert, 1999).

Ultra fine (submicron scale) tungsten powders can be produced from tungstic acid (International Tungsten Industry Association, 2025a; Lassner and Schubert, 1999). These processes are within the refining or intermediate stage of the tungsten supply chain (Figure 3). Traded tungsten metal powders typically contain a minimum of 99.9 per cent W (H C Starck Tungsten Powders, 2025).

Carbides

Tungsten carbide and tungsten semi-carbide have a variety of grades, based on differing physical and chemical properties. Typically, the carbon content of tungsten carbides is around 6 per cent, leaving tungsten carbides as approximately 94 per cent W (H C Starck Tungsten Powders, 2025). Tungsten carbide can be produced from several processes, including:

- carburisation reacts tungsten metal powder with pure carbon powder at 900 to 2000 °C in a furnace
- fluid-bed carburisation reacts either tungsten metal or BTO with a carbon monoxide or dioxide-hydrogen mixture at 900 to 1200 °C
- Melting metallurgy combines tungsten metal and tungsten carbide to form a eutectic system of tungsten carbide and semi-carbide

Further production details are found in Lassner and Schubert (1999).

Carburisation is the conventional process in which submicron to medium (0.15 to 12 µm) and coarse (12 to 50 µm) tungsten carbide powders (and the other listed processes) are used to produce tungsten carbides with a specific particle size and chemical composition (Lassner and Schubert, 1999).

Unwrought bars and rods obtained by sintering

These tungsten forms typically contain a minimum of 99.95 per cent W and are produced from tungsten metal powder. Unlike other metals, unwrought tungsten forms are produced from

compaction and sintering due to the very high melting point of tungsten (Brown and Pitfield, 2014). Tungsten powder is initially compacted in rigid dies or flexible moulds and then sintered at high temperatures (2000 to 3050 °C) to increase the density and strength of the unwrought metal form (Lassner and Schubert, 1999). Sintering is typically performed in a reducing atmosphere using high-purity dry hydrogen to avoid oxidation of the tungsten metal (Lassner and Schubert, 1999). Unwrought tungsten rods and bars are produced at the fabrication stage of the tungsten supply chain (downstream).

Unwrought bars and rods not obtained by sintering

These tungsten forms typically contain a minimum of 99.95 per cent W. Compared to unwrought tungsten bars and rods obtained from sintering, these forms are unwrought and require complex, multistage hot and cold forming processes, including (Lassner and Schubert, 1999):

- rolling (for sheets and rods)
- forging (for rods and large diameter parts)
- swaging (for rods)
- drawing (for wires and tubes)

These tungsten forms are produced at the fabrication stage of the tungsten supply chain (downstream).

Wires

Tungsten wires typically contain a minimum of 99.95 per cent W and are produced from the drawing of tungsten metal rods of approximately 3 mm in diameter through dies to reduce the diameter of the wire to a product specification (Cao et al., 2023). Tungsten wire is produced at the fabrication stage (downstream) of the tungsten supply chain.

Halogen filament lamps

Tungsten-based lamps are commonly produced during the recycling EoL stage of the tungsten supply chain. Lamps that contain tungsten halogen filaments can be separated and sorted from end-use products, such as automobiles, then later processed to extract the filament from other lamp components.

Although HS853921 has poor detail on the specification of the lamps, the CN853921(30; 92; 98) codes specify either the use or the voltage of a lamp. These include:

- tungsten halogen filament lamps for motorcycles and other automobiles
- lamps that have a voltage greater than 100 V
- lamps that have a voltage less than or equal to 100 V

Although the filament is composed of 99.95 per cent tungsten, the mass of a lamp dilutes the contained tungsten of the product. The tungsten content of these lamps can range between 0.01 and 0.07 per cent W (Table 2).

Slags, ash and residues

This refers to metallurgical residues and by-products containing significant tungsten content from smelting and refining operations. These materials can be reprocessed to recover tungsten.

Waste and scrap

Tungsten waste and scrap arise throughout various stages of the tungsten supply chain. They have been classified based on the stage of the tungsten supply chain they were sourced from (old or new scrap) (Brown and Pitfield, 2014) as well as the type of tungsten scrap or waste material (hard or soft scrap) (Lassner and Schubert, 1999). These classifications are mostly synonymous, with ‘hard’ scrap described by Lassner and Schubert (1999) as containing solid metal articles such as tungsten hard metals (cemented carbide parts), tungsten metal and alloy

parts, superalloys and tungsten catalysts. On the other hand, ‘old’ scrap is sorted from EoL products (Brown and Pitfield, 2014).

Soft scrap described by Lassner and Schubert (1999) or ‘new’ scrap described by Brown and Pitfield (2014) mainly contains scrap and waste produced as by-products from the processing of tungsten concentrates, scrap and chemicals in the form of fine particles, powder, dust and sludges. Soft or new scrap can contain tungsten waste articles with a tungsten content between 30 and over 99 per cent; hard or old scrap can contain tungsten waste articles with a tungsten content between 60 and over 99 per cent (Lassner and Schubert, 1999). The intermediate processing of tungsten forms has a high material efficiency driven by tungsten’s high economic value (Leal-Ayala et al., 2015). For this assessment, in the absence of trade code data detailing the flows of various tungsten waste and scrap forms, HS810197 and CN81019700 are assumed to contain 60 per cent tungsten, the median of new and old scrap metal content.

Miscellaneous

This is a catch-all code for remaining materials or products that contain tungsten but do not fit within the HS8110 or CN810199 collection of codes.

European Customs Portal (2025) describes trade code CN81019990 containing the following tungsten products:

- rods (diameter 5 mm; length 100 cm)
- plates (thickness 2 mm; size 50 × 50 cm)
- crucibles (capacity 500 mL)
- wires (diameter 0.1 mm; spool length 1000 m)
- cubes (side length 10 mm)
- tubes (outer diameter 20 mm, inner diameter 15 mm, length 200 cm)
- sheets (thickness 1 mm, size 30 × 30 cm)

Although all these forms of tungsten metals have a minimum purity of 99.95 per cent W (Metalstek, 2025). Other products or forms of tungsten could be reported under this code, such as tungsten metal alloys or superalloys that contain a variety of other alloying metals. For this waste and scrap assessment, BGS made an educated assumption that forms of tungsten within this trade code contained at least 90 per cent W, noting it could be higher or lower.

NOTES ON HARMONIZED SYSTEM (HS) CODES FOR TUNGSTEN IN UN COMTRADE

International and national trade data collated by the UK Government or industrial statistical bodies evolves over time. This can include trade code revisions to represent the changing materials and products traded. The longer the time period included in any study, the greater chance there is that the study will encounter revisions to trade codes. These revisions can be simple, such as a change in code number, and have no effect on monitoring metal flows within the UK. This is the case for tungsten wire, which transitioned from HS810193 to HS810196 during the period encompassed by this study.

Revisions can increase the information on traded commodities, such as the split of HS810191 (unwrought tungsten forms obtained simply by sintering and tungsten waste and scrap) to HS810194 (unwrought tungsten forms obtained from simply sintering) and HS810197 (tungsten waste and scrap). However, other trade code revisions can be more complex, and revisions can conceal traded tungsten forms under all-encompassing descriptions, thereby reducing the resolution of trade information. This is the case for tungsten bars and rods and other tungsten metal forms not obtained from simply sintering, which had the trade code HS810192 in 1996. In the 2002 revision, that trade code transitioned from HS810192 to HS810195. Later, in the 2007 revision, HS810195 was merged into HS810199, which is described as ‘tungsten (wolfram) articles n.e.s…’ (n.e.s. meaning ‘not elsewhere specified’), losing the data resolution for these traded products. These code revisions are presented in Figure 24.

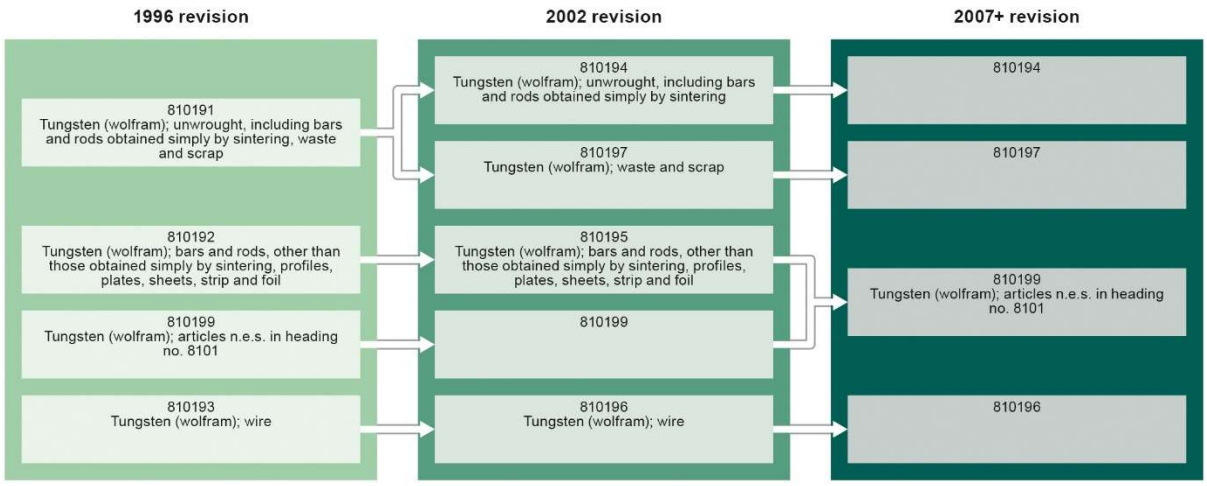

Figure 24 UN Comtrade code revisions through the years for tungsten. Created by BGS based on information from UN Comtrade (United Nations Statistics Division, 2025). BGS © UKRI 2025.

Appendix 2 Brief review of copper mining, processing, smelting and refining

RAW MATERIALS EXTRACTION

Copper is primarily found in the Earth's crust in the form of copper-iron sulfide and copper sulfide minerals, such as chalcopyrite ($CuFeS_2$), bornite (Cu_5FeS_4) and chalcocite (Cu_2S). It can also be present in oxidised copper carbonates, oxides, hydroxy-silicates, and sulfates. In mining, around 80 per cent of all copper ore is sulfide, 19 per cent is oxide, and the other 1 per cent is native copper (Kukula et al., 2024).

Copper sulfide minerals typically occur in low concentrations in a plethora of ore deposit types. Copper content in ores generally ranges from 0.45 per cent in open-pit porphyry copper deposits, like those in South America, to around 1.5 per cent in sediment hosted stratiform or stratabound deposits, like those in the Copperbelt of DRC and Zambia, the Paleoproterozoic basins of Siberia, and the Permian basins of central Europe (Hitzman et al., 2005). These two deposit types are the main hosts of copper ore and likely contribute around 75 and 10 per cent, respectively, of primary copper to global supply (Table 10) (Mudd and Jowitt, 2018b; Mudd et al., 2024). Other deposit types like volcanogenic massive sulfide (VMS), skarn, and iron-oxide-copper-gold (IOCG) deposits all contribute on a minor level to global copper production (Mudd et al., 2024).

Table 10 Copper primary and co-/by-production (Mudd and Jowitt, 2018b; Mudd et al., 2024)

Commodity	Primary Production		Co-/By-Production		
Copper					
	Porphyry	75	Zn-Pb-Cu	VMS	3
	SSC	10	Ni	Magmatic sulfide	3
	IOCG	5	Zn-Pb-Cu	Skarn	2
			Zn-Pb-Cu	Epithermal	1
			Pb-Zn	Sediment hosted	1
			Au	Orogenic gold	0.1

PRIMARY PROCESSING

Sulfide and oxide ores are typically processed by either pyrometallurgy or hydrometallurgy, respectively. However, chalcocite is an exception to this rule as a sulfide that is processed via hydrometallurgy. Comminution is the first step and involves the crushing and grinding of ore into fine powder (Schlesinger et al., 2011).

In pyrometallurgy, comminution is followed by concentration through froth flotation (Aleksandrova et al., 2021). The resulting copper concentrate typically contains about 30 per cent Cu, though this can range from 20 to over 40 per cent Cu. During the next step in the pyrometallurgy process (smelting), the concentrate is heated to high temperatures causing it to separate into molten copper matte and slag. The matte, which contains 50 to 70 per cent Cu and additional iron sulfides, is transferred to a converter, producing blister copper with a purity of around 99 per cent copper (Schlesinger et al., 2011).

The next step is refining, with copper cathode of around 99.99 per cent Cu produced by electrorefining techniques. Melting and continuous casting results in the final product for high-purity copper, typically Grade 1 copper or electrolytic tough pitch copper. Such products contain around 250 ppm oxygen and less than 20 ppm of impurities, making them suitable for nearly all industrial and electrical applications (Schlesinger et al., 2011).

In hydrometallurgy, heap leaching is followed by SX-EW to produce copper cathodes. The final stage involves melting and casting of electro-refined and electrowon cathodes. This process yields three primary product forms:

- continuous rectangular bars, which are rolled into rods and drawn into wire
- round billets (logs), used for extrusion and drawing into tubes
- flat strips, which are rolled into sheets and formed into welded tubes

Most of these products are made from tough pitch copper, which is cathode copper containing 100 to 500 ppm dissolved oxygen introduced during the melting and casting process. A smaller portion of unalloyed copper is produced as oxygen-free high conductivity copper, containing only 5 to 10 ppm oxygen (Schlesinger et al., 2011).

SMELTING PROCESSES

Matte smelting is the most widely used method for processing copper-iron-sulfur (Cu-Fe-S) concentrates. This process produces three main outputs (Schlesinger et al., 2011):

- molten matte (Cu-Fe-S): contains 45 to 75 per cent Cu, which is sent to a converter for further oxidation into metallic copper
- molten iron silicate slag: processed to recover residual copper and then either sold or stockpiled
- sulfur dioxide-rich offgas: cooled, cleaned, and used in sulfuric acid production

The following section describes the three most used commercial smelting processes (Schlesinger et al., 2011):

- Flash smelting is a commonly used technology in copper matte production. It involves injecting dried copper concentrate, oxygen-enriched air, flux, and recycled materials into a reaction shaft at around 1250°C. The sulfide particles oxidize rapidly in the reaction shaft where the concentrate is suspended in air and reacting mid-flight. This process generates heat and is almost autothermal. Flash smelting produces molten matte (around 65 per cent Cu), iron-silicate slag (1 to 2 per cent Cu), and sulfur dioxide-rich offgas (30 to 70 volume per cent SO_2).
- Outotec (formerly Outokumpu) is a leading copper production method, handling about half of global matte smelting. It injects a mix of oxygen, air, dried concentrate, flux, and recycled materials into a high-temperature shaft, enabling rapid, energy-efficient reactions. Operating with minimal fuel, it relies on heat from iron and sulfur oxidation. The process produces high-grade matte, low-copper slag, and sulfur dioxide-rich offgas suitable for sulfuric acid recovery. Automated controls ensure consistent quality and low energy use. Its popularity stems from high throughput, low emissions, and efficient sulfur dioxide capture. However, it cannot smelt scrap, which remains its primary limitation.
- Side-blown tuyere is the third most common copper smelting process. In this process, the tuyeres (nozzles or pipes through which oxygen-enriched air is injected into the molten baths) are positioned horizontally along the side walls of the furnace as opposed to submerged below the matte-slag bath like in Teniente (popular in Chile), Noranda and Vanyukov smelters. The tuyere process, side-blown or not, is highly efficient due to the intense stirring of molten material caused by submerged blowing which enhances heat and concentrate distribution, accelerates reactions, and prevents magnetite (Fe_3O_4) buildup. It also allows for the smelting of scrap and reverts, which are copper-containing materials that are recycled back into the smelting processes to optimise conditions and reduce copper losses. Matte at up to 74 per cent Cu can be produced through the tuyere process, thus reducing energy and oxygen consumption, environmental impact and overall processing time as well as increased copper recovery. The world's highest

capacity smelter, Nanko in China, uses side-blown smelter technology (International Copper Study Group, 2024).

PRODUCTION STATISTICS FOR MINING, SMELTING AND REFINING OF COPPER FROM 2014 TO 2023

Copper production is concentrated in a few key countries, each playing a distinct role in the mining, smelting, and refining stages, shown in Figure 25.

Chile leads global copper mining, producing over 5.37 million tonnes in 2023, which is 23.4 per cent of the world's total mined copper. Chile is followed by DRC with 3.15 million tonnes (13.7 per cent) and Peru with 2.76 million tonnes (12 per cent) (Idoine et al., 2025). Escondida in Chile is the world's largest copper mine with an annual production capability of 1350 kt, followed by Grasberg in Indonesia at 800 kt, and Collahuasi in Chile at 600 kt (International Copper Study Group, 2024).

China dominates the global smelting landscape, processing 11.83 million tonnes in 2023, which is 55 per cent of the world's smelted copper. Japan and Chile follow distantly, contributing 5.5 per cent and 5.0 per cent, respectively (Idoine et al., 2025). In 2023 the Nanko copper smelter in China led global smelting capacity at around 675 kt per year, using a side-blown smelting process. Guixi, operated by Jiangxi Copper Corporation and also located in China, followed with 520 kt and employs flash smelting. India's Adani smelter ranked third at 500 kt. Several other major smelters, including Chuquicamata (Chile), Hamburg (Germany), and Saganoseki (Japan), each had capacities of 450 kt per year (International Copper Study Group, 2024). Smelting technologies varied across the leading smelters, with flash smelting, Outokumpu (or Outotec) and side-blown processes being the most common (International Copper Study Group, 2024).

In 2023, China produced around 12.99 million tonnes of refined copper, accounting for 47.1 per cent of the global total. The DRC and Chile also play significant roles, producing 2.21 million tonnes (8.0 per cent) and 2.08 million tonnes (7.5 per cent), respectively (Idoine et al., 2025). In 2023, the world's largest copper refineries were predominantly located in China, with Guixi leading with a capacity of 1100 kt per year. Other major Chinese refineries include Jinchuan Gansu and Shandong Fangyuan, each with 700 kt per year capacity. India also features prominently, with Birla and Adani refineries each having around 500 kt per year capacity. Outside of Asia, notable facilities include Chuquicamata in Chile and Amarillo in the USA, both with 450 kt per year capacity. Most refineries use electrolytic processes, though Tenke Fungurume in the DRC employs electrowinning, reflecting regional variations in refining technology and feedstock (International Copper Study Group, 2024).

SOME NOTES ON RECYCLING COPPER WASTE AND SCRAP

There are three main sources of recoverable copper from EoL vehicles (Schlesinger et al., 2011):

- copper radiators: typically found in older, industrial, or heavy-duty vehicles (aluminium has largely replaced copper in more recent models).
- copper wires and circuits:
    - Zorba fraction: usually recovered from the non-ferrous scrap stream after vehicle shredding. The mixed non-ferrous fraction, known as Zorba, can be sold directly to copper smelters; however, this increases smelting costs due to the presence of impurities.
    - Zebra fraction: after Eddy-current separation removes non-metallic components, heavy media separation is used to extract aluminium and magnesium. The remaining mix (primarily zinc, brass, and copper) is referred to as Zebra, which can be further upgraded by automatic or manual methods to improve copper purity.
- auto shredder residue: mainly consists of dust and organic materials but can still contain up to 3 per cent Cu, making it a potential but more challenging source.

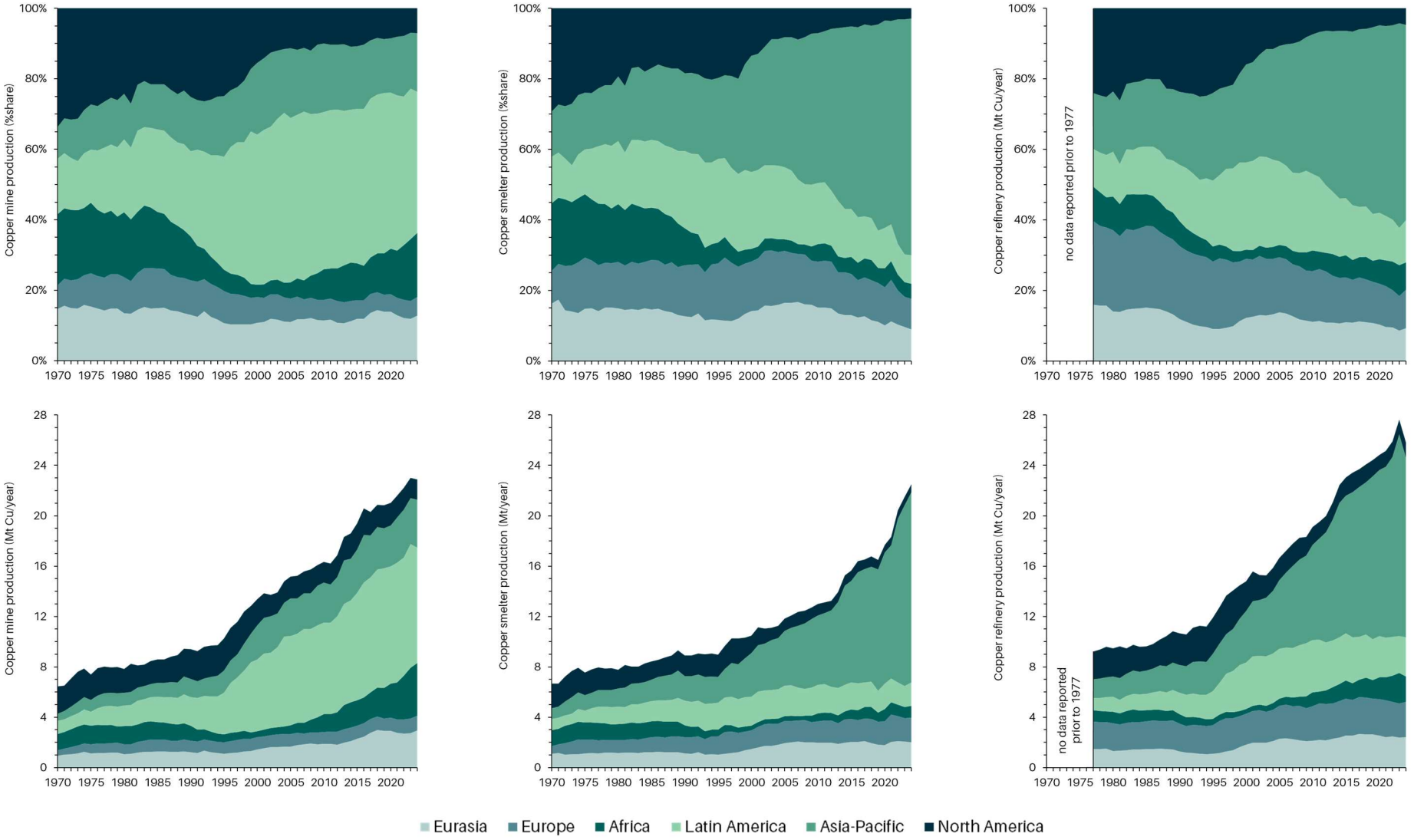

Figure 25 Global copper mine, smelter and refinery production and proportional share from 1970 to 2024 by principal global region (Data from Idoine et al (2024) and previous editions) BGS © UKRI 2025.

Appendix 3 Descriptive comparison of Prodcom and UK trade information codes, including notes on UK production and notable companies

COPPER

All company details found on https://www.uktradeinfo.com/find-uk-traders; companies are indicative only and search is not exhaustive.

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441100	7401	74010000	Copper mattes; cement copper "precipitated copper"	Copper mattes (granulated, 50 kg bags)	Not applicable	Not applicable
				Cement copper (precipitated copper, powdered, 25 kg drums)		
				Copper mattes (solid blocks, 100 kg each)		
				Cement copper (precipitated copper, fine particles, 10 kg containers)		
				Copper mattes (crushed form, 75 kg sacks)		
				Cement copper (precipitated copper, coarse granules, 30 kg boxes)		
		74011000	Copper mattes	2006-2007: 7401100 moved to 74010000	Not applicable	Not applicable
		74012000	Cement copper (precipitated copper).	2006-2007: 7401200 moved to 74010000		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441200	7402	74020000	Copper, unrefined; copper anodes for electrolytic refining	Unrefined copper, 99.9% purity, in ingots weighing 25 kg each	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/
				Copper anodes for electrolytic refining, 99.5% purity, in rectangular plates measuring 100 cm x 80 cm x 5 cm		
				Unrefined copper, 98.8% purity, in granules packed in 50 kg bags		
				Copper anodes for electrolytic refining, 99.7% purity, in slabs weighing 150 kg each		
				Unrefined copper, 99.2% purity, in billets weighing 30 kg each		
				Copper anodes for electrolytic refining, 99.6% purity, in sheets measuring 120 cm x 90 cm x 6 cm		
24441330	7403	74031100	Copper, refined, in the form of cathodes and sections of cathodes	Refined copper cathodes, weighing 3.5 tons each, in rectangular shapes	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/
				Sections of refined copper cathodes, measuring 1.2 meters in length and 0.8 meters in width		
				Cathodes of refined copper alloy, weighing 2.8 tons each, with a thickness of 10 cm		
				Refined copper cathode sections, each weighing 1.5 tons, in irregular shapes		
				Rectangular refined copper cathodes, measuring 1 meter in length and 0.5 meters in width, weighing 2 tons each		
				Sections of refined copper alloy cathodes, with a total weight of 3 tons, in various sizes		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441330	74031	74031200	Copper, refined, in the form of wire-bars	Copper, refined, in the form of wire-bars (weight: 50 kg, diameter: 10 cm, length: 1 m)	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/
				Copper, refined, in the form of wire-bars (weight: 75 kg, diameter: 12 cm, length: 1.2 m)		
				Copper, refined, in the form of wire-bars (weight: 60 kg, diameter: 11 cm, length: 1.1 m)		
				Copper, refined, in the form of wire-bars (weight: 80 kg, diameter: 13 cm, length: 1.3 m)		
		74031300	Copper, refined, in the form of billets	Copper, refined, in the form of billets (weight: 500 kg)	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/
				Copper, refined, in the form of billets (diameter: 150 mm)		
				Copper, refined, in the form of billets (length: 2 meters)		
				Copper, refined, in the form of billets (weight: 1 ton)		
				Copper, refined, in the form of billets (diameter: 200 mm)		
				Copper, refined, in the form of billets (length: 1.5 meters)		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441330	74031	74031900	Copper, refined, unwrought (excl. copper in the form of billets, wire-bars, cathodes and sections of cathodes)	Copper, refined, unwrought, in rectangular slabs (weight: 500 kg, size: 200 cm x 100 cm x 5 cm)	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/
				Copper, refined, unwrought, in irregular ingots (weight: 300 kg, size: 150 cm x 80 cm x 10 cm)		
				Copper, refined, unwrought, in cylindrical blocks (weight: 250 kg, size: 120 cm x 50 cm diameter)		
				Copper, refined, unwrought, in square blocks (weight: 400 kg, size: 180 cm x 180 cm x 6 cm)		
				Copper, refined, unwrought, in trapezoidal shapes (weight: 350 kg, size: 160 cm x 90 cm x 8 cm)		
				Copper, refined, unwrought, in oval forms (weight: 450 kg, size: 210 cm x 110 cm x 7 cm)		
	74032 + 7405	74032100	Copper-zinc base alloys "brass" unwrought	Copper-zinc base alloys (brass) unwrought, 500 kg	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/ Smiths Metal Centres Ltd https://www.smithmetal.com/copper.htm
				Copper-zinc base alloys (brass) unwrought, 1.2 meters in length		
				Copper-zinc base alloys (brass) unwrought, 750 kg		
				Copper-zinc base alloys (brass) unwrought, 2.5 meters in length		
				Copper-zinc base alloys (brass) unwrought, 300 kg		
				Copper-zinc base alloys (brass) unwrought, 1.8 meters in length		
				Copper-zinc base alloys (brass) unwrought, 400 kg		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441330	74032 + 7405	74032200	Copper-tin base alloys "bronze" unwrought	Copper-tin base alloy (bronze) unwrought, 98% copper, 2% tin, 50 kg	Not applicable	Cobra Met UK Ltd https://cobrametukltd.com/ Smiths Metal Centres Ltd https://www.smithmetal.com/copper.htm
				Unwrought bronze, copper-tin base alloy, 95% copper, 5% tin, 25 kg		
				Bronze unwrought, copper-tin alloy, 97% copper, 3% tin, 100 kg		
				Unwrought copper-tin base alloy (bronze), 96% copper, 4% tin, 75 kg		
				Bronze unwrought, copper-tin base alloy, 99% copper, 1% tin, 60 kg		
		74032900	Copper alloys unwrought (excl. copper-zinc base alloys "brass", copper-tin base alloys "bronze", and copper master alloys of heading 7405)	Copper-nickel alloy unwrought, 500 kg		
				Copper-silicon alloy unwrought, 300 kg		
				Copper-aluminium alloy unwrought, 250 kg		
				Copper-manganese alloy unwrought, 400 kg		
				Copper-nickel-zinc alloy unwrought, 350 kg		
				Copper-iron alloy unwrought, 450 kg		
				Copper-magnesium alloy unwrought, 200 kg		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
24441330	74032 + 7405	74050000	Master alloys of copper (excl. phosphorus-copper compounds "copper phosphide" containing by weight > 15% phosphorus)	Master alloys of copper (excluding copper phosphide) with a phosphorus content ≤ 15% by weight	Not applicable	Not applicable
				Copper master alloys containing silicon, weighing 25 kg per unit		
				Master alloys of copper with added nickel, measuring 0.5 meters in length		
				Copper master alloys blended with iron, packaged in 10 kg ingots		
				Master alloys of copper incorporating zinc, with a total weight of 50 kg per shipment		
				Copper master alloys combined with manganese, in 30 cm diameter discs		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
38322300	7404	74040010	Waste and scrap, of refined copper (excl. ingots or other similar unwrought shapes, of remelted refined copper waste and scrap, ashes and residues containing refined copper, and waste and scrap of primary cells, primary batteries and electric accumulators)	Waste and scrap, of refined copper, in the form of shredded cables (weight: 250 kg) Waste and scrap, of refined copper, consisting of pipe fragments (size: 2-5 cm diameter) Waste and scrap, of refined copper, from electrical wiring (length: 10-20 cm) Waste and scrap, of refined copper, as small sheet cuttings (thickness: 1 mm) Waste and scrap, of refined copper, in the form of coil remnants (weight: 150 kg) Waste and scrap, of refined copper, from broken machinery parts (size: 15 cm x 10 cm)	Not applicable	European Metal Recycling (EMR): one of the UK's largest metal recyclers, with multiple sites handling copper scrap Sims Metal Management UK: a global leader in metal recycling, active in refined copper scrap exports H J Enthoven Ltd (part of the Ecobat group): known for non-ferrous recycling, including copper S Norton & Co Ltd: a major UK-based scrap metal processor and exporter Mettalis Recycling Ltd: specialises in non-ferrous scrap, including copper wire and refined copper residues

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
38322300	7404	74040091	Waste and scrap, of copper-zinc base alloys "brass" (excl. ingots or other similar unwrought shapes, of remelted waste and scrap of copper-zinc alloys, ashes and residues containing copper-zinc alloys and waste and scrap of primary cells, primary batteries and electric accumulators)	Waste and scrap of copper-zinc base alloys (brass), consisting of plumbing fixtures and fittings, weighing approximately 500 kg	Not applicable	European Metal Recycling (EMR): one of the UK's largest metal recyclers, with multiple sites handling copper scrap Sims Metal Management UK: a global leader in metal recycling, active in refined copper scrap exports H J Enthoven Ltd (part of the Ecobat group): known for non-ferrous recycling, including copper S Norton & Co Ltd: a major UK-based scrap metal processor and exporter Mettalis Recycling Ltd: specialises in non-ferrous scrap, including copper wire and refined copper residues
				Waste and scrap of copper-zinc base alloys (brass), including discarded industrial machinery parts, measuring 10 cm x 15 cm		
				Waste and scrap of copper-zinc base alloys (brass), comprising broken valves and connectors, with a total weight of 750 kg		
				Waste and scrap of copper-zinc base alloys (brass), from dismantled electrical components, in pieces ranging from 5 cm to 20 cm		
				Waste and scrap of copper-zinc base alloys (brass), sourced from automotive radiators, weighing 300 kg		
				Waste and scrap of copper-zinc base alloys (brass), derived from old musical instruments, in various sizes up to 50 cm		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
07291990	2617	26179000	Ores and concentrates (excl. iron, manganese, copper, nickel, cobalt, aluminium, lead, zinc, tin, chromium, tungsten, uranium, thorium, molybdenum, titanium, niobium, tantalum, vanadium, zirconium, precious-metal or antimony ores and concentrates)	Excluding copper	Not applicable	Glencore Plc: global mining company and commodity trader with UK offices; major copper miner (but not in UK) Trafigura UK Ltd: a global commodities trading house with a growing footprint in copper concentrate markets Concord Resources Ltd: London-based metals trading firm active in non-ferrous commodities Ocean Partners UK Ltd: specialises in base metal concentrates and has a strong presence in copper trading International Copper Traders Ltd: a newer UK firm involved in trading ores and metals

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
38322940	2620	26203000	Slag, ash and residues containing mainly copper	Slag containing mainly copper (weight: 500 kg, size: granular)	Not applicable	European Metal Recycling (EMR): one of the UK's largest metal recyclers, with multiple sites handling copper scrap Sims Metal Management UK: a global leader in metal recycling, active in refined copper scrap exports H J Enthoven Ltd (part of the Ecobat group): known for non-ferrous recycling, including copper S Norton & Co Ltd: a major UK-based scrap metal processor and exporter
				Ash residues with predominantly copper content (weight: 300 kg, size: fine powder)		
				Residues from incineration containing mainly copper (weight: 450 kg, size: coarse particles)		
				Copper-rich slag from non-ferrous metal processing (weight: 600 kg, size: mixed granularity)		
				Ash containing primarily copper compounds (weight: 350 kg, size: fine dust)		
				Residues from smelting with mainly copper content (weight: 550 kg, size: irregular chunks)		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
38322940	2620	26209995	Slag, ash and residues containing metals or metal compounds (excl. those from the manufacture of iron or steel and those containing primarily zinc, lead, copper, aluminium, nickel, niobium, tantalum, tin or titanium, those containing arsenic, mercury, thallium or their mixtures of a kind used for the extraction of arsenic or those metals or for the manufacture of their chemical compounds and those containing antimony, beryllium, cadmium, chromium or their mixtures)	excluding copper	Not applicable	Not applicable

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
20121240	2825	28255000	Copper oxides and hydroxides	Copper (II) oxide (CuO), a black powder used in ceramic glazes and pigments.	Not applicable	Thermo Fisher Scientific UK: supplies high-purity copper compounds for lab and industrial use Alfa Aesar (part of Thermo Fisher): offers copper oxides for research and specialty applications
				Copper (I) oxide (Cu2O), a red powder used as a fungicide and in antifouling paints.		
				Copper (II) hydroxide (Cu(OH)2), a blue solid used in the production of rayon and as a fungicide.		
				Basic copper carbonate (Cu2(OH)2CO3), a green compound used in pigments and as a wood preservative.		
				Copper oxychloride (Cu2(OH)3Cl), a green powder used as a fungicide and in agriculture.		
20133150	2827	28274100	Chloride oxides and chloride hydroxides of copper	Chloride oxide of copper (CuClO)		Thermo Fisher Scientific UK: offers a wide range of copper compounds for lab and industrial use Alfa Aesar (part of Thermo Fisher): supplies high-purity copper chlorides for research and specialty applications ReAgent Chemicals Ltd: UK-based chemical manufacturer and distributor that handles copper salts Merck Life Science UK (formerly Sigma-Aldrich): distributes copper chlorides for scientific and industrial use
				Chloride hydroxide of copper (CuClOH)		
				Chloride oxide of copper (CuClO2)		
				Chloride hydroxide of copper (CuCl(OH)2)		
		28274990	Chloride oxides and chloride hydroxides (excl. copper, lead and mercury)	excluding copper		

ProdCom SIC	CN	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Copper Products
20134165	2833	28332500	Sulphates of copper	Copper (II) sulphate pentahydrate ($CuSO_4 \cdot 5H_2O$) (250 g)	Not applicable	Not applicable
				Anhydrous copper sulphate ($CuSO_4$) (500 g)		
				Copper sulphate monohydrate ($CuSO_4 \cdot H_2O$) (1 kg)		
				Basic copper sulphate ($Cu_4(SO_4)(OH)_6 \cdot 2H_2O$) (750 g)		
				Copper sulphate solution (10% w/v) (2 L)		
		28332980	Sulphates (excl. of sodium, magnesium, aluminium, nickel, copper, barium, cadmium, chromium, zinc, cobalt, titanium, lead and mercury)	excluding copper		

TUNGSTEN

All company details found on https://www.uktradeinfo.com/find-uk-traders; companies are indicative only and search is not exhaustive.

ProdCom SIC	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Tungsten Powder and Products
24453013	81011000	Tungsten powders	Tungsten powder (99.9% purity, 10 kg) Tungsten powder (grain size 1-5 microns, 5 kg) Tungsten powder (spherical, 2 kg) Tungsten powder (recycled, 15 kg) Tungsten powder (nano-grade, 500 g) Tungsten powder (99.95% purity, 8 kg)	The exact amount of 99.9% purity tungsten powder produced in the UK is not publicly available. There is no readily available data on the specific production volume for a particular purity and quantity like 10 kg of tungsten powder. The UK does have companies that produce tungsten powder and tungsten products, but detailed production figures are typically not disclosed.	Hallamshire Hardmetal Products Ltd: Specializes in tungsten carbide components, serving various industries like oil and gas, toolmaking, and engineering. Wolfmet: Produces tungsten and tungsten heavy alloys, including tungsten powder. Elemental Microanalysis Ltd: Suppliers of tungsten (VI) oxide powder, a precursor to tungsten powder, according to Volza. Testbourne Ltd: Suppliers of tungsten oxide targets. Additionally, some companies listed on the ADS Group website may focus on tungsten components rather than powder production.

ProdCom SIC	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Tungsten Powder and Products
24453013	81019400	Unwrought tungsten, incl. bars and rods of tungsten obtained simply by sintering	Unwrought tungsten bars (weight: 5 kg, length: 50 cm) obtained by sintering Unwrought tungsten rods (diameter: 2 cm, length: 1 m) obtained by sintering Unwrought tungsten bars (weight: 10 kg, length: 75 cm) obtained by sintering Unwrought tungsten rods (diameter: 3 cm, length: 1.5 m) obtained by sintering Unwrought tungsten bars (weight: 15 kg, length: 60 cm) obtained by sintering	The exact amount of 99.9% purity tungsten powder produced in the UK is not publicly available. There is no readily available data on the specific production volume for a particular purity and quantity like 10 kg of tungsten powder. The UK does have companies that produce tungsten powder and tungsten products, but detailed production figures are typically not disclosed.	Hallamshire Hardmetal Products Ltd (as noted above) Hartmetall UK Ltd: Established as a distributor of tungsten carbide wear parts, they also stock and supply tungsten carbide rods. Tungsten Alloys Ltd: This company supplies a range of high-density tungsten alloys and other specialized metals tailored to specific requirements. Wolfmet Ltd: Produces tungsten and tungsten heavy alloys, including tungsten powder.
	81019600	Tungsten wire	Tungsten wire (diameter 0.5 mm, length 50 meters) Tungsten wire scrap (weight 2 kg) Tungsten wire (diameter 1.2 mm, length 100 meters) Tungsten wire for industrial use (diameter 0.8 mm, length 30 meters) Recycled tungsten wire (weight 1.5 kg) Tungsten wire (diameter 0.3 mm, length 20 meters)	The exact amount of 99.9% purity tungsten powder produced in the UK is not publicly available. There is no readily available data on the specific production volume for a particular purity and quantity like 10 kg of tungsten powder. The UK does have companies that produce tungsten powder and tungsten products, but detailed production figures are typically not disclosed.	Elemental Microanalysis Ltd: a notable supplier of tungsten oxide in the UK. They may also handle tungsten wire (Volza.com). ALFA AESAR: a supplier of tungsten oxide in the UK (Volza.com). Testbourne Ltd: a tungsten oxide supplier (Volza.com).

ProdCom SIC	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Tungsten Powder and Products
24453013	81019910	Tungsten bars and rods (other than those obtained simply by sintering), profiles, plates, sheets, strip and foil, n.e.s.	Tungsten bars, 10 mm diameter, 1 meter length Tungsten rods, 5 mm diameter, 2 meters length Tungsten profiles, T-shaped, 15 mm width, 3 meters length Tungsten plates, 500 mm x 500 mm, 10 mm thickness Tungsten sheets, 1 meter x 2 meters, 2 mm thickness Tungsten strip, 50 mm width, 5 meters length, 1 mm thickness Tungsten foil, 100 mm x 100 mm, 0.1 mm thickness	The exact amount of 99.9% purity tungsten powder produced in the UK is not publicly available. There is no readily available data on the specific production volume for a particular purity and quantity like 10 kg of tungsten powder. The UK does have companies that produce tungsten powder and tungsten products, but detailed production figures are typically not disclosed.	Special Metals Solutions Ltd: tungsten bars, rods, plates, sheets, strips. Hallamshire Hardmetal Products (as noted above) Dymet Alloys: They manufacture tungsten products like centerless ground rod, cut-to-length rod, and shaped electrode components. They also offer tungsten for anode, cathode, and glass applications. Hartmetall (UK) Ltd: specialty alloys, carbides and chemicals MGS Precision Ltd: They supply tungsten heavy alloys in rod, bar, plate, and sheet forms, as well as finished machined parts.

ProdCom SIC	CN8	CN description	Products that are included in CN Data source: European Customs Portal (2025)	UK production data	UK Companies Possibly Producing Tungsten Powder and Products
24453013	81019990	Articles of tungsten, n.e.s.	Tungsten rods (diameter 5mm, length 100cm) Tungsten plates (thickness 2mm, size 50x50cm) Tungsten crucibles (capacity 500ml) Tungsten wires (diameter 0.1mm, spool length 1000m) Tungsten cubes (side length 10mm) Tungsten tubes (outer diameter 20mm, inner diameter 15mm, length 200cm) Tungsten sheets (thickness 1mm, size 30x30cm)	The exact amount of 99.9% purity tungsten powder produced in the UK is not publicly available. There is no readily available data on the specific production volume for a particular purity and quantity like 10 kg of tungsten powder. The UK does have companies that produce tungsten powder and tungsten products, but detailed production figures are typically not disclosed.	Special Metals Solutions Ltd (as noted above) MGS Precision Ltd (as noted above) Future Alloys Ltd: supplies high-quality pure tungsten materials in various forms, including blocks, rods, bars, strip, sheets, plates, wire, cubes, crucibles, and ingots. Wolfmet (as noted above) Lint Steels Ltd: manufactures tungsten sheets and plates and provides testing and quality packaging for their products. Hallamshire Hardmetal Products (as noted above) Midland Carbides Ltd: manufacturer of tungsten carbide products. Tungsten West Plc: a mining development company focused on restarting the Hemerdon tungsten mine in the UK. Other potential suppliers (e.g. ADS Group directory) include Aero Metals Alliance UK Limited, Dymet Alloys Ltd, Burcas Ltd.

Appendix 4 Key historical UK copper refineries

Actid Ltd (1964)

This was an electrolytic copper refinery based near Glasgow, producing copper from scrap (McMahon, 1964). It was acquired by the Wolverhampton Metal Company in 1966 (Grace's Guide to British Industrial History, n.d.-a). No data are available on its establishment or closure dates.

British Insulated Callender's Cables – Prescot (1891 to 1991)

The British Insulated Wire Company opened a smelting and refining plant at Prescot, near Liverpool, between 1891 and 1906 to convert scrap copper into wire bars. A larger refinery, operated by British Insulated Callender's Cables (BICC), was built in 1932 to import and reprocess high-grade copper. From 1935 to 1978, annual production of billets, slabs, and wire bars ranged from 50 000 to 105 000 tonnes, with 65 000 t of cathode copper produced in 1979 (Dickinson et al, 1996). By 1961, BICC had acquired British Copper Refiners, adding an output of 55 000 tonnes Cu per year (Grace's Guide to British Industrial History, n.d.-b). A reverberatory furnace processed blister "pigs" (98 to 99 per cent Cu) imported from Rhodesia (Grace's Guide to British Industrial History, n.d.-b).

By 1964, Prescot's combined fire-refining and electrolytic capacity was 100 000 tonnes Cu per year; in 1959, fire-refined output was 80 000 tonnes Cu and electrolytic output 7 000 tonnes Cu (McMahon, 1964). The site also housed a copper-cadmium alloy plant (peak 20 000 tonnes per year in the 1960s) and a brass foundry until the 1980s. Subsequent closures occurred mid-1980s to 1988, with metal processing ceasing in 1991 (Dickinson et al., 1996; Grace's Guide to British Industrial History, n.d.-b). A rod-rolling plant opened in 1976, processing 100,000 t/year of 99.99 % pure cathode copper (Dickinson et al., 1996).

Conflicting accounts state that BICC was formed in 1945 by merging British Insulated Cables Ltd and Callender's Cable & Construction Co Ltd (Web Archive, 2007).

Burry Port Copper Works (1849 to 1912)

The Burry Port smelting furnace near Llanelli began producing refined ingots and sheets in 1849, becoming a leading primary smelter until international competition forced its closure in 1912 (Pembrey & Burry Port Heritage, n.d.). It may be related to Elkington Copper Refiners but it's not explicitly stated.

Cambrian Metal Co Ltd (around 1919 to mid-1930s)

Established post-World War I in Burry Port, South Wales, Cambrian Metal Company refined largely secondary feedstocks until closure in the mid-1930s (Pembrey & Burry Port Heritage, n.d.).

Capper Pass and Son Ltd. (1912 to 1991)

Formed in 1912 and located at Bristol and North Ferriby, Capper Pass produced electrolytic copper, tin, lead, antimony, and silver (McMahon, 1964). The Bristol works closed in 1964 (Grace's Guide to British Industrial History, n.d.-c), and the company ceased operations entirely in 1991 (Litten & Strachan, 1995).

Elkington Copper Refiners Ltd. (1949 to 1986)

Named as Elkington & Co and Elkington, Mason and Co, this company pioneered commercial electrolytic refining at Pembrey, near Burry Port, in around 1865 (Gore, 1894). Acquired by Elliott Metal Co in 1894 (Gore, 1894). By about 1903, the plant at Pembrey produced approximately 6 000 tonnes of electrolytic refined copper per year (Mackey and Wraith, 2004). The plant closed before 1910, suspected to be the result of the consolidation of the company's copper production in Birmingham (Mackey and Wraith, 2004) with a fire- and electrolytic-refining site at Walsall in 1949 (The National Archives, n.d.-Elkington). Fire capacity was 15 000 tonnes per year and electrolytic 10 000 tonnes per year (McMahon, 1964). Alloy ingot production ceased by 1968, but cathode output continued until 1974. IMI Ltd acquired the company in 1986 (The National Archives, n.d.-Elkington).

Enfield Rolling Mills (1924 to 1980)

Founded 1924 at Brimsdown, north London, Enfield Rolling Mills added a copper refinery in 1939, producing wire bars, billets, and cakes (Grace's Guide to British Industrial History, n.d.-d). Annual rod and rolled copper and brass output was approximately 58 000 tonnes (Antique Metalware Society, n.d.). Delta Metal Co acquired ERM in 1963, and the Birmingham and Bradford sites closed in 1980 (Antique Metalware Society, n.d.; Grace's Guide to British Industrial History, n.d.-d).

Hafod & Morfa / British Copper Manufacturers (to 1980)

Swansea's Hafod and Morfa works merged in 1924 to form British Copper Manufacturers; Imperial Chemical Industries (ICI) acquired and rebranded them in 1928 as Yorkshire Imperial Metals, shifting to manufactured products (Hughes & Reynolds, 1989; Halford & Sherman, 2014). The sites were closed by 1980 (Hughes & Reynolds, 1989; ERIH, n.d.).

James Bridge Copper Works (1917 to 1999)

Acquired in 1920 by Wolverhampton Metal Co, James Bridge Copper Works refined and smelted copper from scrap but faced shutdowns over emissions in 1931, reopening in 1932 (The National Archives, n.d.-JBCW). World War II blackouts closed it again until 1945. By 1953, it led the UK's reclamation of waste copper (The National Archives, n.d.-JBCW). By 1964, it had smelting and electrolytic capacity producing anodes, cakes and cathodes (McMahon, 1964). IMI acquired it in 1967 (The National Archives, n.d.-WMC), renamed it IMI Refiners Ltd in 1971, and added continuous anode casting (34 000 tonnes per year) and upgraded refining tanks (57 000 tonnes per year) by 1972 (Owen and Jacobi, 1975). By 1974 it was the UK's largest scrap refinery (The National Archives, n.d.-WMC). It adopted the Isa process in 1992 (Armstrong, 1999) but closed in 1999 (West Midlands Combined Authority, 2019; Newman, 1999).

McKechnie Brothers Ltd (1891 to 1964)

Established 1891 at Widnes, it refined copper, silver, copper sulfate, and powder; operations continued until 1964 (Grace's Guide to British Industrial History, n.d.-e).

Thomas Bolton & Sons Ltd. (1964)

This company was established in 1783 with two plants in Lancashire (Lancaster–Mersey Copper Works at Widnes and Sutton Rolling Mills at St Helens) and two in Stafford at Froghall and Oakamoor. The Widnes works smelted and refined brass and copper residues and other copper-bearing scrap for the manufacture of Musey-brand copper sulfate. It also refined blister copper and processed scrap. The refinery at Froghall dealt with electrolytic cathode copper and processed scrap from other works (McMahon, 1964). By 1975, the company became part of BICC Industrial Products. By 1984, there was a merger of the copper and aluminium business of BICC and Johnson and Firth Brown with sites at Froghall and Wakefield in Yorkshire (Grace's Guide to British Industrial History, n.d.-f). It is uncertain when it closed but may have closed like BICC in 1991.

White Rock Copper Works (closed 1929)

Once one of the largest copper smelters in Swansea, the White Rock works closed in 1929 due to cheaper ore smelting elsewhere, particularly in Cornwall. Its closure led to the cessation of large-scale primary smelting in South Wales (Musgrove, 2011).

Yorkshire Copper Works (1880s to 1980)

Founded in the late 1880s as Elmore's Patent Copper Depositioning Company, the works evolved into Leeds Copper Works by 1902 and rebranded as Yorkshire Copper Works in 1909. The First World War provided great expansion with the production of shell bands, condenser tubes and a piercing mill that started in 1917. The expansion of the petrochemical industry led to large scale production of copper and copper-alloy tubing. At the start of 1958, the copper works merged with Imperial Chemical Industries Ltd. to form Yorkshire Imperial Metals Limited (Burton, 2023). By 1980, the Yorkshire Copper Works announced its closure (Morton, 2018).

Conflicting evidence: David J Scown (5th March 2018) replies stating that Yorkshire Copper Works closed in 2016 (Morton, 2018). A different news article states closure of the Yorkshire Copper Works in 1997 (Burton, 2023).

Abbreviations and acronyms

AMT	Ammonium metatungstate
APT	Ammonium paratungstate
BEV	Battery electric vehicle
BGS	British Geological Survey
BTO	Blue tungsten oxide
CIF	Cost of goods, insurance and freight
CMIC	Critical Minerals Intelligence Centre
CN codes	Combined Nomenclature codes (EU)
DBT	Department for Business and Trade
DRC	Democratic Republic of the Congo
EoL	End-of-life
EoW	End-of-waste
ESG	Environmental, social and governance
EU	European Union
EV	Electric vehicle
EWC	European Waste Catalogue
FOB	Free-on-board
HS codes	Harmonized System codes (global)
ICE	Internal combustion engine
IOCG	Iron-oxide-copper-gold (mineral deposit)
MFA	Material flow analysis or assessment
PVC	Polyvinyl chloride
R2	Coefficient of correlation
SIC	Standard industry code
Sintering	Forming a solid by pressure or heat without melting it into a liquid
SX-EW	Solvent extraction-electrowinning
USGS	United States Geological Survey
VAT	Value-added tax
WDI	Waste Data Interrogator (UK Environment Agency)
YTO	Yellow tungsten oxide

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The British Geological Survey holds most of the references listed below, and copies may be obtained via the library service subject to copyright legislation (contact libuser@bgs.ac.uk for details). The library catalogue is available at: https://ukrinerc.on.worldcat.org/discovery.

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