UK Critical Minerals Intelligence Centre

Waste classification: a review of UK practice to improve circularity

Decarbonisation and Resource Management Programme

Commissioned Report OR/26/054



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Waste classification: a review of UK practice to improve circularity

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Foreword

This report is the published product of a study by the UK Critical Minerals Intelligence Centre (CMIC), hosted by the British Geological Survey (BGS). It was commissioned by the Department for Business, Innovation, Science and Trade (BIST) as part of the 2026/27 work programme for CMIC. CMIC supports the UK Government's objective of securing resilient, responsible and sustainable critical mineral supply chains that strengthen economic prosperity and national security.

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Summary

Critical minerals are essential to modern technologies, industrial processes and critical infrastructure, yet increasing geopolitical, economic and environmental pressures have exposed vulnerabilities within global supply chains. Such vulnerabilities underline the need for robust assessments to inform policy development and identify effective risk mitigation measures.

This report explores the extent to which UK waste classification and management frameworks influence the recovery of critical minerals and support the transition to a more circular economy. It highlights that end-of-life (EoL) products, manufacturing residues and industrial waste streams are emerging as increasingly important secondary sources of critical minerals. More effective recovery of these materials could enhance the UK's supply-chain resilience, contribute to net zero objectives and reduce reliance on imported primary raw materials.

The research identifies several challenges that currently limit the recovery and recycling of critical minerals, including:

- regulatory frameworks that have largely evolved to manage both waste and environmental risks rather than maximise secondary resource recovery
- substantial gaps in data on material stocks, flows and losses
- the widespread 'downcycling' of materials, resulting in losses of critical minerals
- shortages of specialist skills, particularly in metallurgy, materials science and recycling
- techno-economic constraints, including high energy costs, technological uncertainty and commodity price volatility, which can discourage investment in recycling and recovery infrastructure

The study also identifies considerable opportunities to expand secondary supply. Many EoL products or waste streams contain concentrations of critical minerals that are comparable to or even exceed those considered feasible for recycling or those found in mineral deposits. The rapid deployment of low-carbon technologies, including electric vehicles, wind turbines and photovoltaics, is expected to generate increasing volumes of recoverable EoL materials in the future. These developments indicate significant potential for EoL products to contribute to meeting future demand for certain critical minerals.

Realising this opportunity will require a coordinated approach across industry and Government. Improved monitoring and traceability of materials through mechanisms such as digital product passports and robust chain-of-custody systems will be essential. Greater alignment between UK policy and international standards will also help secure access to secondary material feedstocks and facilitate international trade in recovered materials. In addition, manufacturers will need to embrace circular design principles that prioritise durability, repairability, re-usability and recyclability, enabling products to retain their value for longer and increasing the efficiency of material recovery at the end of their useful life.

Achieving the ambitions set out in the UK Critical Minerals Strategy (Department for Business and Trade, 2025) will require a more integrated policy framework that brings together waste management, circular economy principles and objectives, and critical mineral supply-chain resilience. Success will depend on:

- improving the availability and quality of data
- creating supportive and proportionate regulatory frameworks
- investing in collection, separation and processing infrastructure as well as specialist skills
- maintaining strong international collaboration to ensure secure and sustainable access to critical mineral resources

1 Introduction

Minerals[1] are essential to many sectors of a modern economy, including:

- digital infrastructure and information technology
- energy generation
- medical diagnoses and treatments
- food and fibre production
- civil and transport infrastructure, products and technologies
- defence infrastructure and technologies
- water and waste-water services

Through a systematic analysis known as a 'criticality assessment', those minerals considered to be at risk of supply disruption and whose shortage could have significant economic impacts are identified as 'critical' minerals. The 2024 UK Criticality Assessment (Mudd et al., 2024) designated 34 minerals as critical to the UK economy.

The production of minerals and the manufacture of products and technologies[2] are intertwined with waste generation through residues, unused materials and offcuts, all of which require careful assessment and management. At end-of-life (EoL), products and technology components become waste unless they can be repurposed or recycled. All waste will contain a variety of minerals, many of which could be critical.

In the UK, recycling of metals such as copper and gold dates to the Bronze Age and iron to the Iron Age; lead, tin and antimony were being recycled as early as the Middle Ages (Raymond, 1984). This shows that recycling is a long-established resource management strategy that reduces waste and keeps materials in use (Kuijpers, 2019). Other strategies to improve resource efficiency include repurposing (re-using a product for a new use after the original use has ended), refabrication (modifying a product for re-use or a new use), demand reduction through product design and/or consumer education or substitution (where feasible). Collectively, improving or extending the use of materials in the economy is commonly referred to as ‘circularity’ or the ‘circular economy’ (Kuijpers, 2019). However, the modern re-use and recovery of minerals contained in waste or EoL is commonly low (Graedel et al., 2011), despite many efforts to improve it. By increasing the contribution of secondary resources, the circular economy can strengthen supply-chain resilience, reduce dependence on primary extraction and lessen the impacts of global mineral supply chains.

Known as ‘Vision 2035’, the UK Critical Minerals Strategy (Department for Business and Trade, 2025) includes a core pillar of greater circularity to improve supply-chain resilience and reduce impacts from primary demand. Vision 2035 aims to achieve a 20 per cent recycling rate for critical minerals by 2035 (excluding iron, due to the significant recycling rates already in place). However, the currently low rates of recycling or circularity for most critical minerals (Graedel et al., 2011) suggest that it is worthwhile examining how waste materials are classified and managed, as these provide the foundation for changing the consumer behaviour, industry practices and regulatory frameworks that can facilitate greater circularity (see International Energy Agency, 2021, 2024; Worrell and Reuter, 2024a).

This report presents a high-level review of the current practices, challenges and opportunities in the UK that relate to the critical minerals contained within a variety of waste streams associated with common EoL products, with particular attention paid to how waste streams are currently

[1] We use the term 'minerals' to be inclusive of elements in their metal, mineral or material forms.
[2] We consider products to be a single technology (for example, laptop computers; electric vehicles) and technologies to be systems providing a service (for example, energy; telecommunications).

classified. The study aims to provide a foundation for future thinking within the sector, including the need for consumer, industry and regulatory evolution in support of societal objectives and government policy priorities.

The report covers:

- a brief review of the conceptual framework for waste and the more circular economy (Section 2)
- reviews of regulatory practices in key jurisdictions (Section 3)
- analyses of import and export of waste and scrap by principal element (Section 4.1)
- case studies of critical minerals in common EoL products (EV traction motors and batteries, wind turbines, smartphones) as precursors for wastes derived from these (Section 4.2)
- review of future potential secondary supplies in the UK from decarbonisation technologies (Section 4.3)
- issues, concerns and opportunities noted through industry stakeholder engagement (Section 5)

Waste streams, especially those generated during product manufacture and at EoL, represent an important potential secondary source of critical minerals in the UK. Examples include:

- EoL electric vehicle (EV) batteries: aluminium, cobalt, copper, graphite (as carbon), lithium, manganese, nickel and phosphorus
- EoL EV drive trains: iron–rare earth element–boron magnets in synchronous motors
- waste electrical and electronic equipment (WEEE): cobalt, copper, gallium, germanium, indium, lithium, platinum group elements (PGEs), rare earth elements (REEs), tantalum, etc.
- scrap metals from aerospace, industrial machinery and manufacturing waste: copper, PGEs, REEs (from turbine magnets and EV motors), titanium, tungsten, etc.

2 Waste and the circular economy: framing the challenges and opportunities

The EU's Waste Framework Directive[3] defines waste as 'any substance or object which the holder discards or intends or is required to discard'. In the UK, waste is considered to be material that someone or an organisation has discarded, either unintentionally, involuntarily, accidentally or, in some circumstances, by law[4]. This means that the material has no fit-for-purpose use and becomes excluded from economic activity or, in reality, there is a cost for disposing of it in some fashion.

The common aspects in both definitions of 'waste' are that:

- a material no longer has any useful function
- the holder of that material makes a decision to consider the material as waste (within the bounds of the various policy, economic and technological limits and opportunities that may apply)

There are various implications from this overall approach, including:

- the need to improve re-use potential
- developing new technology for reprocessing or repurposing
- examining the economics of waste disposal
- assessing systems dynamics and modelling material flows more comprehensively

Waste from industrial processes used to be discharged into the natural environment. As industrialisation grew, the impacts from this practice increased substantially. From the 1970s, developed economies introduced environmental regulations to mitigate impacts, incentivise waste treatment and recycling, and enforce environmental protection at waste-disposal sites that were engineered for containment. The primary goals were to protect human and ecological health.

The process of extracting resources, using them and then disposing of products and waste without recycling is referred to as the 'linear economy' (Clark, 2016; Worrell and Reuter, 2024b). The linear economy assumes that both resources and the environment's capacity to absorb waste are unlimited. However, resources are only available from within our planetary boundary and the impacts of waste disposal can be significant, to the point of ecological collapse in extreme cases.

The analogy between recycling in natural systems on our planet and our anthropogenic or industrial systems was termed 'industrial ecology' by Graedel (1996), where three essential system types were recognised:

- Type 1: an ecological system with unlimited energy and resources and no restrictions on waste outputs (linear economy)
- Type 2: situations where energy and resource inputs are limited, meaning that waste outputs are also typically limited
- Type 3: the only effective input is solar energy and everything is recycled within our planetary systems, noting that this can range from days to millennia or geological epochs (Earth represents this system)

Graedel's approach is simply illustrated in Figure 1, highlighting the key role that systems thinking plays in understanding waste and its flows, especially within anthropogenic or industrial

[3] https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en
[4] https://www.gov.uk/guidance/check-if-your-material-is-waste

systems. To further emphasise the economic nature of industrial systems, this field is now broadly termed the ‘circular economy’, reflecting the circular processes of the way our planet naturally works.

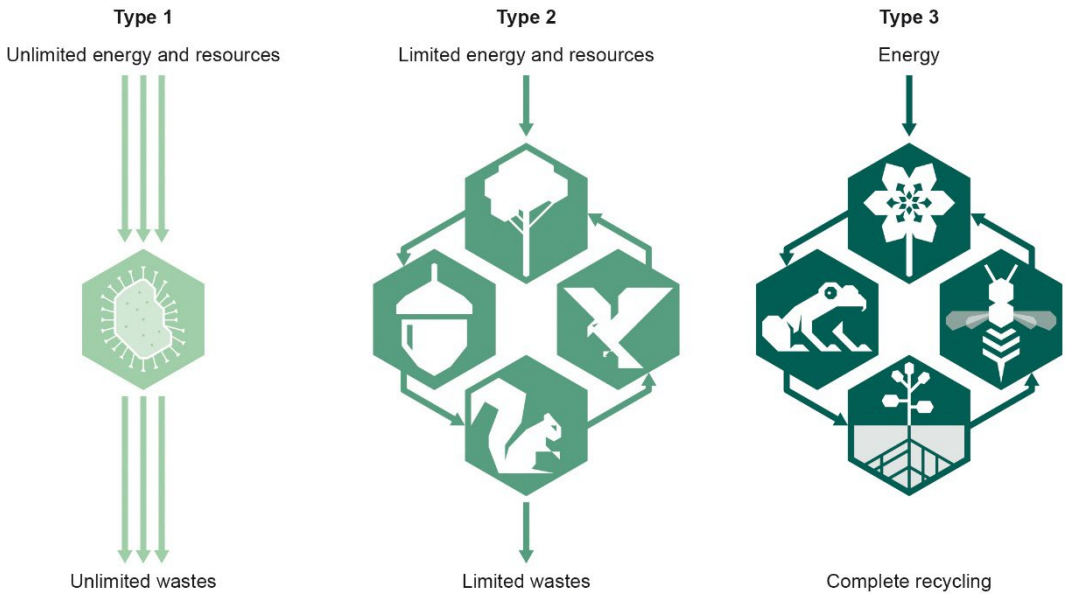


Figure 1 Different types of energy and resource flows in different ecological systems (re-drawn from Graedel (1996); Graedel and Allenby (2010)).

In effect, this means that we need to consider the boundaries of resource and waste flows within our economy, especially from a systems perspective, and how to assess and understand the ways to manage waste flows. This is especially relevant when considering the metals or minerals still contained within waste and their potential for recycling. We also need to consider the UK economy not as a Type 1 organism or completely independent on its own, but as a Type 3 system that has interrelated flows with other economies, countries or regions. In other words, we need to facilitate imports and exports of resource and waste flows, which is a key pillar of the UK Critical Minerals Strategy (Department for Business and Trade, 2025).

The supply chains for critical minerals are complex and transnational, with materials often crossing national borders multiple times before arriving in a final product or technology. The flows of critical minerals within principal supply-chain stages and subsequent EoL collection, processing and recycling is shown in Figure 2.

A single country has very limited opportunity to control how global supply chains operate, especially where primary mineral extraction occurs as well as subsequent processing and manufacturing. Secondary supply chains, however, can provide the same raw materials as primary supply through the collection, recycling and recovery of EoL products and technologies: in other words, waste can be processed to recover the numerous minerals within it (Figure 2). This is the reason for the close relationship between strategies for critical minerals and the circular economy. Effective collection and sorting systems are therefore crucial for ensuring that waste is recovered and recycled. A key challenge is that EoL products and technologies invariably contain several different minerals and materials, meaning that the waste requires sorting systems or other processing techniques to separate valuable materials for efficient, cost-effective recycling.

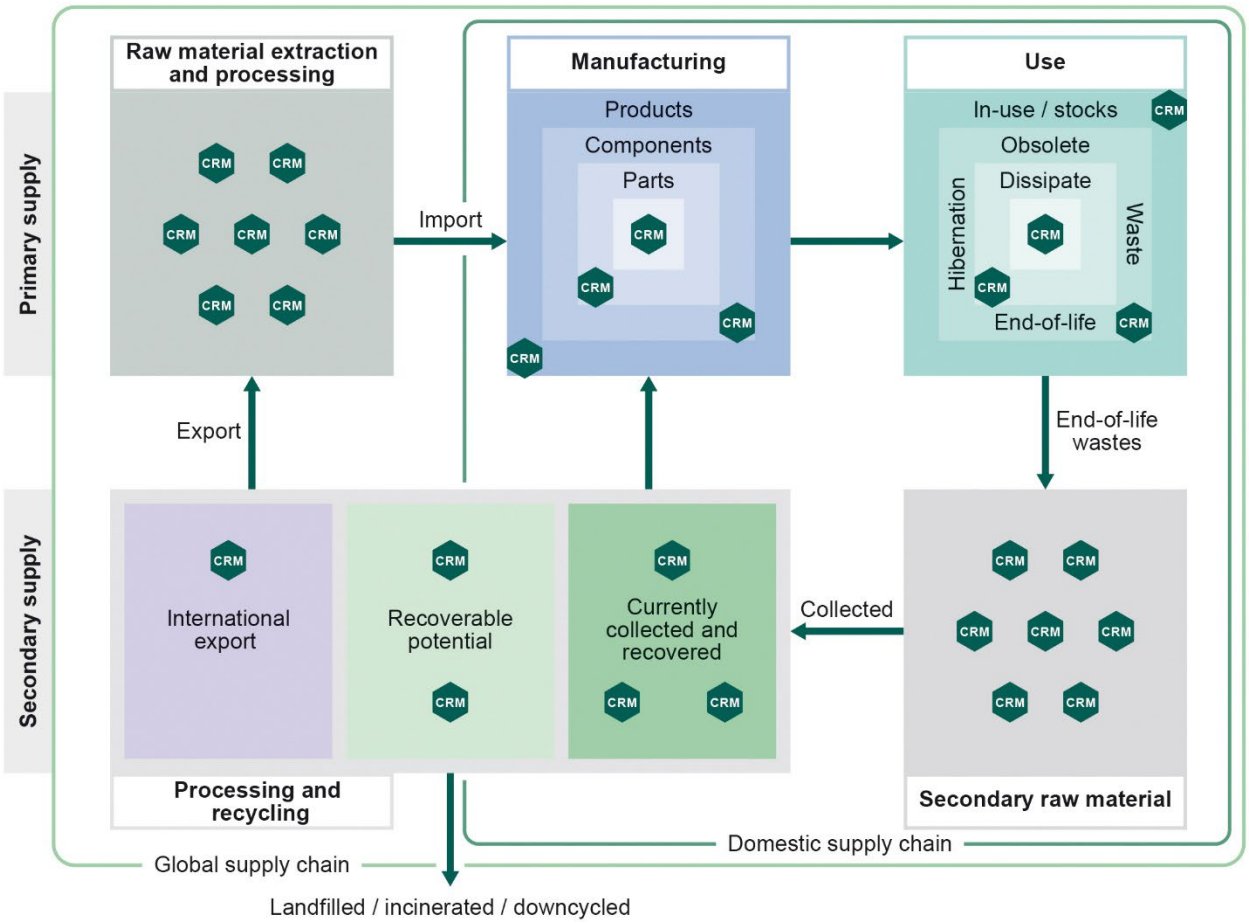


Figure 2 Essential stages in the flows of critical minerals in supply chains, products through to end-of-life collection, recycling and recovery. CRM: critical raw material. BGS © UKRI 2026.

As shown in **Figure 2**, it is important to consider the flows and stocks of critical minerals within each stage of a supply chain. For example, germanium used in small electronics such as smartphones or laptops may only be in active use for a few years but, if used in optical fibre within a telecommunications system, it could stay in active use for a few decades or longer.

When a particular use reaches EoL, the product or technology becomes potentially available for collection and recycling. It is therefore important to understand both the amounts or quantities at each supply-chain stage for each product or technological use as well the flows occurring at all steps. From a supply-chain systems perspective, the quantities of stocks can be represented as shown in **Figure 3**.

Waste can be:

- highly dispersed: for example, EoL products such as smartphones may remain in homes long after active use
- highly complex: smartphones contain more than 60 minerals and materials
- highly variable in composition: especially geographically and over time

Waste collection is also typically expensive (for example, Worrell and Reuter, 2024b). These factors present fundamental challenges in mapping critical minerals in waste streams: the biggest challenge is not having a good understanding of the bills of materials (a list of all the raw materials, components, assemblies, and quantities required to manufacture, assemble, or construct a product or technology), meaning it is difficult quantify the opportunities that may flow through to waste streams derived from these sources. An example is the lack of a detailed

inventory of materials in a smartphone over time and what this means for electronic waste or its constituent component parts such as screens, batteries, main circuit boards, etc.

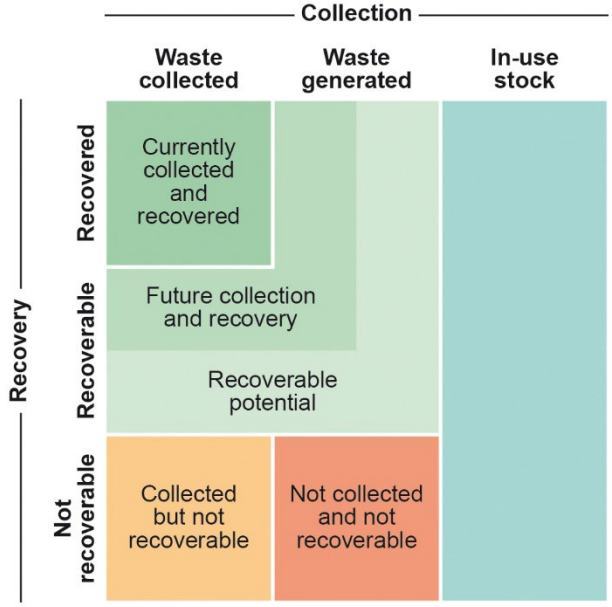


Figure 3 Conceptual view of stocks or quantities involved during in-use and waste supply-chain stages and their collection and recovery, where applicable (adapted from Kippert et al., 2025).

These challenges are commonly addressed through a combination of consumer education, regulatory requirements, corporate policy and economic incentives to encourage and facilitate higher collection rates and enable recycling and recovery. For example, the minerals contained in spent process catalysts are not traded as waste; rather, the catalysts themselves are regenerated through reprocessing into fresh catalysts, meaning that recycling is a service-based business model rather than a trade in minerals or materials. Alternatively, some commonly used metals such as iron (steel), aluminium, lead and copper are easy to collect at EoL (for example, steel beams; metal pipes; cabling) and can be straightforward to repurpose, re-use or recycle rather than being disposed of. This also provides an additional supply to that from primary mining. This demonstrates the need to view recycling from both a product and a material perspective, such as the REEs used in permanent magnets within EVs and wind turbines.

The extent of consumer, regulatory, corporate and business models to facilitate recycling can vary widely across all critical minerals and is beyond the scope of this review.

3 Approaches to waste classification and reporting

At its simplest, waste can be considered as any material, residue, product or technology that is no longer required for its intended purpose and therefore needs processing or disposal. Although it is not always easy to discern when this might occur, waste can arise due to (amongst others):

- processing and manufacturing stages
- reaching EoL
- redundancy (a new product, technology, etc. has replaced an old one)
- failure
- accident

Given the potentially hazardous nature of waste, regulatory requirements are typically detailed and prescriptive in classifying it into different categories, thereby facilitating decisions regarding its management.

Here we briefly review the principal frameworks that exist at the international level, in the UK and in the EU.

3.1 INTERNATIONAL CONTEXT

The emergence of environmental regulations in the 1970s in developed nations led to some waste being disposed of in developing nations, invariably with poor to no engineering of disposal sites. Awareness of this issue created international pressure in the 1980s, with efforts leading to the development of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The Basel Convention was adopted in March 1989, with 53 countries and the European Economic Community (known as 'parties to the treaty') signing the treaty by March 1990. It entered into force in May 1992[5]. The Basel Convention prohibits the transport of hazardous waste from parties to non-parties and requires parties to reduce waste generation and provide incentives for pollution prevention associated with waste generation, management, treatment and disposal.

The movement of waste internationally is strongly regulated through both the Basel Convention and a range of regulatory instruments adopted by both exporting and importing nations. In general, waste must be classified and declared, risk assessments prepared (especially to facilitate the ability of emergency services to respond to an accident, should one occur) and stringent transport requirements be in place. While the process can be lengthy and costly, it is recognised as crucial to ensure the safe transport and management of waste.

It should also be recognised that international trade in waste continues, especially since recycling infrastructure and businesses typically lag behind the rapid evolution of products and technologies. For example, waste electrical and electronic equipment (WEEE) continues to make its way to unprepared parts of the world labelled as 'second-hand use', leading to serious environmental and human health risks and impacts (for example, Baldé et al, 2024).

There are also a range of other regulatory measures or regimes in operation in countries around the world, although they are out of scope for this review.

[5] https://www.basel.int/theconvention/overview/history/overview/tabid/3405/default.aspx

3.2 UNITED KINGDOM

Regulations regarding how waste is classified and subsequently handled in the UK must adhere to the Environment Act 2021 (UK Parliament, 2021). There are lead agencies within each devolved nation of the UK which maintain policies and responsibilities for enacting regulations for waste management, classification and disposal or recycling (outlined further below). The classifications derived from the Waste Framework Directive are detailed in the Environment Agency's Technical Guidance WM3 for waste classification (Environment Agency, 2021) for England, which are also referenced by other devolved nations. Due to this, it should be recognised that there are complexities and can be differences across devolved nations, depending on waste type and other factors in applying the regulations. In general, once a material is classified as waste it needs to be dealt with according to UK and EU regulations (this ensures international regulatory consistency and interoperability by businesses). All waste should be classified by the producer of the waste and this classification passed on to the next holder of the waste. This is part of Waste Duty of Care (Section 34(1) Environment Protection Act 1990) as outlined in Waste Duty of Care: Code of Practice (Department for Environment Food & Rural Affairs, 2018). The requirements include whether the waste is hazardous or not and identifies the destination as well as information that would enable the waste to be managed legally, without harm to health or the environment.

Given that waste policy and regulation is devolved to each nation of the UK, operators working across borders within the UK will need separate permits and face differing requirements relating to the handling, transport, storage and/or treatment of waste. Similarly, definitions of both 'recycling' and 'waste' are different, although they are overarchingly defined by the Waste Framework Directive. For example, differences may arise over the interpretation of what constitutes a ‘discarded’ material when a material is surplus, or what constitutes an industrial by-product. These will be subject to legal tests and regulator judgement as well as various evidence thresholds that may vary between the nations of the UK.

Similarly, different quality requirements can be set on 'end-of-waste' material (when a material is declassified from waste to a resource or industrially usable material). As a result, material such as industrial by-products (for example, excavated material; slag; ashes) may be considered waste in one nation and by-product or recovered material in another. This highlights the need to carefully consider the relevant end-of-waste criteria that define by-products (for example, synthetic materials or minerals extracted from waste). As an example, the Scottish Environment Protection Agency (SEPA) and the Environment Agency (EA) in England have different requirements for material specifications for re-use of incinerator bottom ash (the non-combustible residue after municipal solid waste has been burned).

The different criteria for the different nations can be found as follows:

- England: https://www.gov.uk/guidance/check-if-your-material-is-waste
- Northern Ireland: https://www.daera-ni.gov.uk/articles/legal-definition-waste
- Scotland: https://beta.sepa.scot/topics/waste/waste-guidance/
- Wales: https://naturalresources.wales/guidance-and-advice/environmental-topics/waste-management/how-to-classify-and-assess-waste?lang=en

Regulation is also focused on household waste collection and biodegradable waste handling. There is very little consideration of the content of this waste, especially critical minerals. There are no specific policies or regulations on critical minerals in the UK regarding either waste or the circular economy, although there are broad categories of waste that may help in identifying the likely presence of certain critical minerals (for example, WEEE; see Section 4.2). The National Planning Policy Framework (NPPF) states that "relevant development plan policies should take account of the contribution that substitute, secondary and recycled materials, and minerals waste, can make to the supply of materials." (page 51, Ministry of Housing Communities and Local Government, 2026). The NPFF also states that substantial weight should be given to the

benefits of extracting and processing critical minerals. Together, these provisions help ensure that planning decisions recognise existing supply chains for secondary raw materials and that minerals wastes are included in planning decisions around primary raw material extraction.

However, critical minerals may be indirectly covered by polices relating to product design and EoL management, such as extended producer responsibility (EPR) in England or zero waste policy in Wales. For example, the EPR policy in England requires producers to pay for the collection and recycling of aluminium packaging in an effort to increase secondary aluminium supply[6]. Also, the Welsh government's 'Beyond Recycling' strategy specifically deals with waste streams with direct relevance to critical minerals, for example commitments for the collection of WEEE, and discusses the importance of critical raw materials (CRMs) with regard to retaining their value in use and diversifying supply (Welsh Government, 2021).

One significant difference is data availability: there is no UK-wide consistent dataset that includes both mass (or volume) and contents. Although the respective regulatory agencies provide some level of data on waste arisings, the datasets are reported at different resolutions and rely on different data collection methods:

- England: Waste Data Interrogator[7] (from the EA)
- Northern Ireland: local authority collected municipal waste management statistics[8]
- Scotland: Scottish Official Waste Statistics[9] (from SEPA)
- Wales: local authority municipal waste management[10]

These datasets contain numerous differences; for example, data for England has a high spatial resolution and is broken down by individual sites, whereas data for Wales is broken down by local authority areas. Similarly, England and Scotland use European waste codes for reporting, however data for Wales is instead broken down by material groups. The statistics are therefore not directly comparable. A synthesis of the lead regulator, principal policies, data and other information relevant for waste classification for England, Scotland, Wales and Northern Ireland is shown in Table 1.

3.3 EUROPEAN UNION

The EU Waste Framework Directive (2008/98/EC)[11] established the foundation of the EU waste management policy, aiming to protect human health and the environment by reducing waste generation, minimising waste-related impacts and improving resource efficiency. It has since been strengthened to tackle the EU's reliance on imported critical minerals through key amendments, notably EU Directive 2018/851[12], which promotes waste prevention and the circular economy, and the 2023 Batteries Regulation[13], which introduces enhanced requirements for battery sustainability through proper management of the waste from the different stages of the batteries' life cycle.

[6] https://www.legislation.gov.uk/uksi/2024/1332/contents
[7] https://www.gov.uk/guidance/how-to-access-waste-management-data-for-england#waste-data-interrogator
[8] https://www.daera-ni.gov.uk/articles/northern-ireland-local-authority-collected-municipal-waste-management-statistics
[9] https://shiny.data.gov.scot/sepa/waste/index.html
[10] https://www.gov.wales/local-authority-municipal-waste-management#latest-release
[11] https://eur-lex.europa.eu/eli/dir/2008/98/oj/eng
[12] https://eur-lex.europa.eu/eli/dir/2018/851/oj/eng
[13] https://eur-lex.europa.eu/eli/reg/2023/1542/oj/eng

Table 1 Concise, high-level summary of how waste classification is managed in England, Scotland, Wales and Northern Ireland.

Area	Document, policy or description	Link
England		
Regulator	Environment Agency (EA)	https://www.gov.uk/government/organisations/environment-agency
Relevant policy documents	No circular economy specific policy	
Notable devolved policies	Extended Producer Responsibility (EPR) Standardised household waste collection Business waste to be separated (dry recyclables and commercial food)	
Data	Waste Data Interrogator	https://www.gov.uk/guidance/how-to-access-waste-management-data-for-england#waste-data-interrogator
Other comments	Waste collection differs greatly across local authorities	
Northern Ireland		
Regulator	Northern Ireland Environment Agency, within the Department of Agriculture, Environment and Rural Affairs	https://www.daera-ni.gov.uk/articles/northern-ireland-environment-agency
Relevant policy documents	Environmental Improvement Plan for Northern Ireland No circular economy specific policy Rethinking Our Resources: Northern Ireland resources and waste management strategy (draft consulted in 2026)	https://www.daera-ni.gov.uk/publications/environmental-improvement-plan-northern-ireland
Notable devolved policies	Currently in draft	
Data	Northern Ireland local authority collected municipal waste management statistics	https://www.daera-ni.gov.uk/articles/northern-ireland-local-authority-collected-municipal-waste-management-statistics
Other comments	The recent lack of an executive has hindered implementation	

Area	Document, policy or description	Link
Scotland		
Regulator	Scottish Environment Protection Agency (SEPA)	https://www.sepa.org.uk/
Relevant policy document	Circular Economy (Scotland) Act 2024 Scotland's Circular Economy & Waste Route Map to 2030	https://www.legislation.gov.uk/asp/2024/13 https://www.gov.scot/publications/scotlands-circular-economy-waste-route-map-2030/
Notable devolved policies	Landfill restrictions (for example, biodegradable waste bans) Deposit return scheme proposals (currently delayed due to national legislation — UK internal market act)	
Data	Scottish Official Waste Statistics	https://data.gov.scot/sepa/waste/index.html
Other comments	Scotland is specifically noted as embedding critical minerals in its circular economy implementation in the UK critical mineral strategy	
Wales		
Regulator	Natural Resources Wales	https://naturalresources.wales/
Relevant policy document	Beyond Recycling: a strategy to make the circular economy in Wales a reality (2021) Towards Zero Waste (2023)	https://www.gov.wales/written-statement-beyond-recycling-strategy-make-circular-economy-wales-reality https://www.gov.wales/sites/default/files/publications/2019-05/towards-zero-waste-our-waste-strategy.pdf
Notable devolved policies	Zero waste by 2050 Mandatary household waste separation Business waste to be separated (dry recyclables and commercial food)	
Data	Local authority municipal waste management	https://www.gov.wales/local-authority-municipal-waste-management#latest-release
Other comments	One of the highest recycling rates in the world First UK nation to set statutory recycling targets	

A range of other directives are relevant for specific products or technologies, such as (amongst others):

- End-of-Life Vehicle (ELV) Directive 2000/53/EC[14]
- Waste Electrical and Electronic Equipment (WEEE) Directive 2012/19/EU[15]
- EU Waste Shipments Regulation 1013/2006/EC[16]
- Mining Waste Directive 2006/21/EC[17]

Sections 3.3.1 to 3.3.5 list the main policy initiatives relating to how waste is classified, the implementation of the circular economy and the relevance to critical minerals in EoL products that have been introduced post-Brexit; they are applicable in the EU but not the UK.

3.3.1 Critical Raw Materials Act

The EU's Critical Raw Materials Act (CRMA) of 2024 (European Parliament and Council of the European Union, 2024) is a wide-ranging piece of legislation aimed at reducing the EU's heavy dependence on external suppliers for critical minerals (note that the EU uses the term 'critical raw materials', whereas the UK adopts 'critical minerals'). Although much of the legislation focuses on primary production, it covers the entire raw materials value chain, including recycling and use of waste materials.

Key features or concerns relating to waste and the circular economy:

- at least 25 per cent of EU consumption of strategic raw materials must come from recycling
- increase the recycling capacity for critical materials within Europe (Article 1)
- treat recycling as part of the raw materials value chain
- implement strategic projects (defined in the CRMA as those projects where the EU needs to support for improving critical minerals supply-chain resilience)
- countries must develop national programmes to enhance circularity, including increased collection of critical mineral-rich waste and measures on re-use, recycling and recovery systems (Article 26)
- operators of extractive waste facilities must assess the potential for recovering CRMs (this is mine-tailing focused) (Article 27)
- reporting data relating to project status using the United Nations Framework Classification (UNFC) empowers the commission to define priority products, components and waste streams (for example, batteries; WEEE) with high critical mineral recovery potential
- it is not specified whether recycled critical minerals should originate from EoL products or manufacturing waste
- Digital Product Passports (DPPs) that track a products composition, origin, environmental footprint and EoL recycling guidance

3.3.2 European Green Deal

The European Green Deal 2019 (EGD) (European Commission, 2019) is a broad policy framework made up of multiple directives, regulations and action plans. The most relevant waste and recycling provisions sit within its Circular Economy Action Plan (Section 3.3.3) and associated legislation, such as the Battery Regulation and ELV Directive. It also draws on other, relevant, older legislation such as the Waste Framework Directive and the Waste Shipment Regulation. Regarding critical minerals, it states that 'diversifying supply from both primary and secondary sources' is required to maintain security of supply.

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[14] https://eur-lex.europa.eu/eli/dir/2000/53/oj/eng
[15] https://eur-lex.europa.eu/eli/dir/2012/19/oj/eng
[16] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32006R1013
[17] https://eur-lex.europa.eu/eli/dir/2006/21/oj/eng

3.3.3 Circular Economy Action Plan 2020

Part of the EGD (European Commission, 2019), this will likely be superseded by the Circular Economy Act[18] (in preparation), which is currently due for adoption in late 2026. Regarding critical minerals, it notes that global consumption of materials (including metals and minerals) is expected to double between 2020 and 2060, so countries are required to secure their supplies of key resources, raw materials and products, including by circular economy initiatives such as reducing consumption, increasing resource efficiency.

Key features relating to waste and the circular economy:

- requires collection and recycling of e-waste
- includes targets such as a maximum of 10 per cent of waste sent to landfill by 2035, with significant increases to municipal and packaging-waste recycling
- separate collection of waste streams and expanding re-use systems

3.3.4 Ecodesign for Sustainable Products Regulation

Ecodesign for Sustainable Products Regulation (ESPR) is a single framework regulation to prevent waste generation at source by improving the circularity, resource efficiency and environmental performance of products across their life cycles (European Parliament and Council of the European Union, 2024).

Key features relating to waste and the circular economy:

- mandatory recyclability and recycled content (no specific percentages are defined; they are covered in product-specific delegated acts)
- a digital product passport (DPP) will provide information on material composition (including critical minerals), recycling instructions and disassembly, environmental impacts, and lifecycle data
- waste prevention measures (a ban on destruction of unsold goods) currently only cover textiles but may expand

3.3.5 Batteries Regulation (EU) 2023/1542

The Batteries Regulation is a product-specific regulation building on the EGD and ESPR (European Parliament and Council of the European Union, 2023). It aims to ensure that batteries are collected, re-used and recycled at high rates and that a common set of rules is applied to ensure competitiveness. To support this, ‘black mass’ from waste batteries made of lithium, nickel and zinc (as well as that from sodium-sulfur and alkaline batteries) is now classified as hazardous. A new hazardous code for lithium-based batteries collected separately from municipal rubbish has also been added. New waste codes have been designed to retain black mass longer in the economy, to increase battery recycling and our circular economy.

Key features relating to waste and the circular economy:

- by 2031, batteries must contain minimum levels of recycled content for:
  - cobalt: 16 per cent
  - lead: 85 per cent
  - lithium: 6 per cent
  - nickel: 6 per cent
- producers are responsible for collection, treatment and recycling
- requirement for removability and replaceability
- phasing in of battery passports

[18] https://environment.ec.europa.eu/strategy/circular-economy_en

3.3.6 Classification of EU waste projects and resources: the role of the UNFC

The UNFC is a framework classification developed by the United Nations Economic Commission for Europe. It was designed to classify projects according to a set of consistent criteria, covering all resources including anthropogenic resources (waste, residues and scrap) (United Nations Economic Commission for Europe, 2019). It is notable in a European context regarding classification, as the use of the UNFC is mandatory for several aspects of the CRMA. Recycling and waste are specially mentioned in Article 27; projects must report using the UNFC. This is mainly focused on mine tailings projects rather than recycling projects. However, Article 7, for strategic projects, which does include recycling and waste recovery, also mandates the use of the UNFC for reporting (European Parliament and Council of the European Union, 2024).

As a result of this and other requirements regarding the harmonisation of data around projects and resources (both primary and secondary), the UNFC is becoming increasingly adopted within the EU for such purposes. However, being a completely new initiative, there is still some uncertainty as to how the UNFC can be applied to secondary or recycling projects. Limited work has been undertaken to compare resource classification against primary projects, which often require higher levels of confidence in estimates due to established rules around reporting to public stock or securities exchanges.

A recent Horizon Europe project, 'FutuRaM', has produced several case studies on using the UNFC to classify recycling and secondary raw materials projects. One output of this is the Sara4UNFC tool[19] that produces a structured anthropogenic resource assessment. Such an approach is likely to become adopted in some form across EU recycling and recovery projects.

The FutuRaM project results[20] are now available, including a range of statistical data regarding critical minerals in waste via the Urban Mine Platform. Of particular relevance to the UK, however, is Deliverable 1.2, 'Proposal on secondary raw materials statistics to the EC', which gives lists of PRODCOM[21] waste codes as well as recommendations on how they can be improved (Baldé et al., 2024).

Some important points about the UNFC include:

- the UNFC is a resource classification tool used to quantity resources within a project and the status of that project; it does not specifically relate to the classification of particular waste streams, the content of waste streams or waste definitions
- the use of the UNFC in the UK would align with EU policy and create standardised data, as well as help projects align with EU strategic projects
- there is still a great deal of uncertainty around how well classification of secondary resources and projects compares to the classification of primary projects; however, there are multiple initiatives within the EU being currently undertaken to resolve this
- the UNFC is not the industry standard, but there are no industry standards for secondary projects

[19] https://sara.geologie.geowissenschaften.uni-muenchen.de/
[20] https://futuram.eu/library/deliverables-reports/
[21] 'Production Communautaire' (Community Production)

3.4 CHINA

China tightly regulates waste classification to secure its critical mineral supply chains, prioritising both resource recovery and geopolitical leverage. China classifies waste products containing iron, non-ferrous and precious metals as ‘anthropogenic minerals’ rather than hazardous waste, promoting domestic recycling while strategically restricting the export of raw materials such as REEs. This regulatory framework promotes the systematic recovery of critical metals from WEEE and EoL vehicles.

China defines black mass (from lithium-ion batteries) as a non-waste commodity if it satisfies certain processing requirements, simplifying the extraction of cobalt, lithium and nickel, in contrast to the EU, which classifies it as hazardous waste. However, China launched a nationwide enforcement campaign on the recycling and utilisation of EoL batteries in response to EU battery regulations. The campaign focuses on three verified inspection priorities:

- traceability of batteries repurposed for second-life applications (for example, energy storage)
- completeness and authenticity of battery management systems collected life-cycle data
- verifiability of claimed carbon footprints associated with re-used or recycled battery units

This initiative has a direct impact on global suppliers of battery management systems and energy management systems, particularly those exporting to markets with strict circular economy requirements such as the EU, where compliance with battery traceability, carbon footprint disclosure and EoL responsibility is now under increased scrutiny.

China is also rapidly adopting novel technologies to extract REEs and other critical minerals from legacy mine tailings and industrial by-products like coal ash.

4 Case studies

This section presents selected case studies that explore waste flows for the UK, indicative concentrations of critical minerals and other materials in EoL products and a review of recent research projecting the potential future supply of secondary materials from UK decarbonisation technologies. These provide different perspectives on UK EoL waste and its potential for recycling and greater circularity.

4.1 WASTE AND SCRAP FLOWS FOR THE UK FOR SELECTED METALS

The UK economy has been importing and exporting various forms of metals and minerals for centuries, if not millennia (see extensive data in Mitchell, 1988, 1992), but only since the Industrial Revolution from the late 18th century has the scale of imports and exports become significant — especially throughout the 20th century. Recently, Mudd et al. (2025) showed that imports of primary forms of copper, chemicals and waste and scrap exceeded exports from 1920 to 2003, suggesting the conversion from imported raw material forms to useful goods and products. However, exports exceeded imports significantly from 2004 to 2023, suggesting the release of copper from in-use stocks to waste and scrap for exports. This analysis was only for imported and exported primary forms of copper, as reported through trade data, and was not a comprehensive material flow assessment. The analysis suggests that the UK was now a likely net exporter of copper.

Here, we analyse the waste- and scrap-related trade data for all reported individual metals. We present the average annual flows and values from 2021 to 2025 through UK imports and exports based on UN Comtrade data (United Nations Department of Economic and Social Affairs, 2026). Results are given in Table 2. It should be noted that waste and scrap may include primary forms such as powders which have no HS code of their own (e.g. rhenium).

Longer-term analyses from 1993 to 2025 for the same metals and data series are given in Figure 4, showing that:

- net exports have been a feature since the 1990s for copper, iron, tin and zinc
- net exports have been a feature since the 2000s for aluminium, lead and magnesium
- approximately balanced imports and exports prevail for antimony, chromium, cobalt, molybdenum, nickel and tungsten
- net imports prevail for bismuth, hafnium, rhenium, tantalum, titanium and zirconium

A few metals are relatively stable over time: iron and copper have had consistent net exports while bismuth, cobalt, nickel and tungsten have switched from net imports to exports (albeit at minor scales). However, a feature of many of the metal waste and scrap flows is the change over time, with some showing rapid change at some points (for example, magnesium in the mid-2000s; tin in the mid-2010s; antimony and chromium throughout) or a long-term, gradual trend (for example, tin increasing net exports until the mid-2010s; lead increasing towards net exports). This highlights the need for more detailed assessments of each specific metal to understand stocks and flows, especially as they relate to different uses, their respective residence times in use and associated waste within the UK's ambition for a more circular economy. Holistic and comprehensive material flow analyses (MFAs) provide a more detailed understanding of a metal's stocks and flows, and the options to improve circularity.

We also include the data for electronic waste in Table 2, which, despite the limited four years of data, shows substantial net exports. This is due to the absence of specialist processing facilities for electronic waste in the UK, meaning that it is collected and prepared for export through shredding.

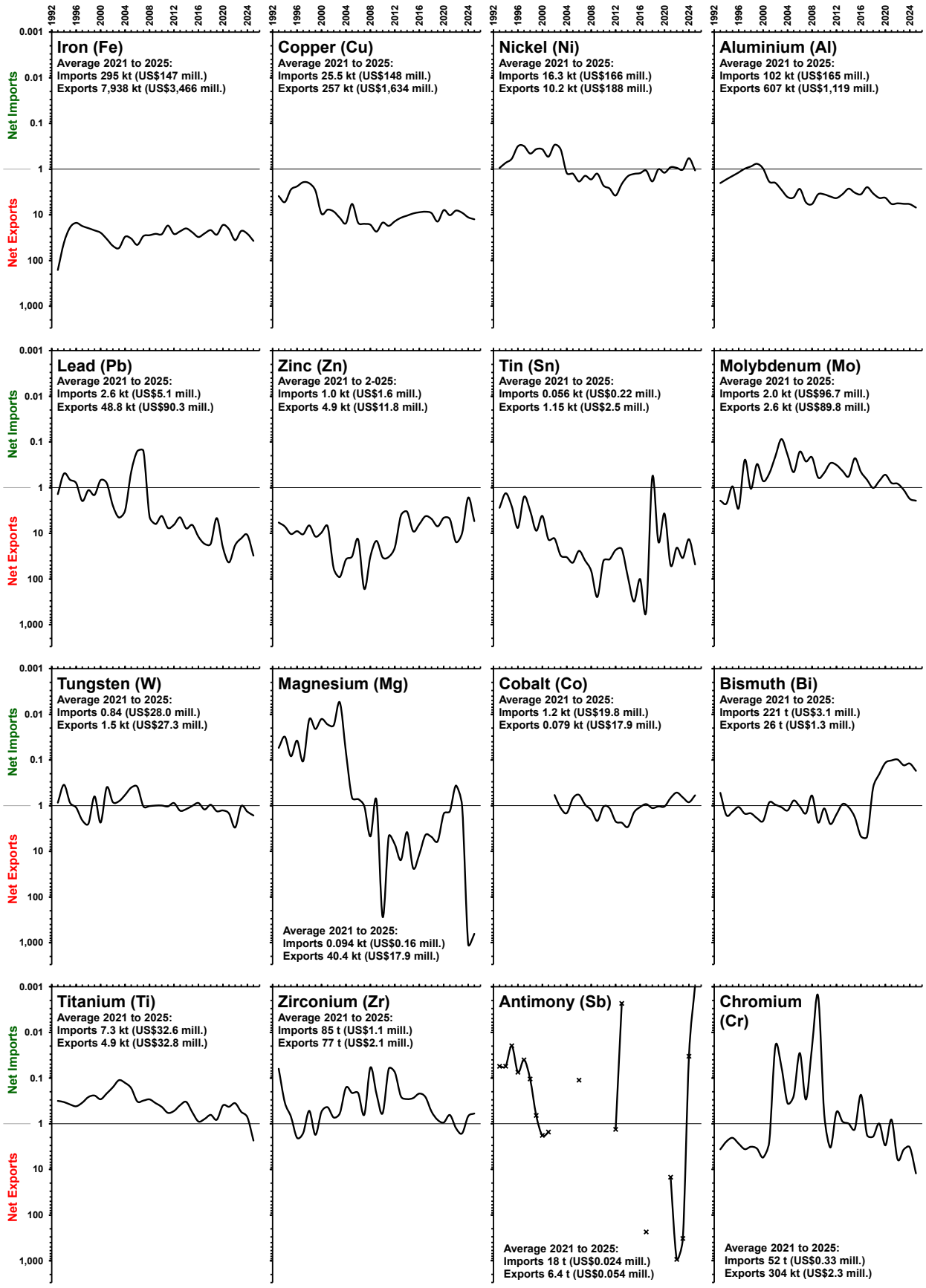


Figure 4 Export/import balance from 1993 to 2025, shown as exports/imports and including average values from 2021 to 2025. (Data from UN Comtrade). BGS © UKRI 2026.

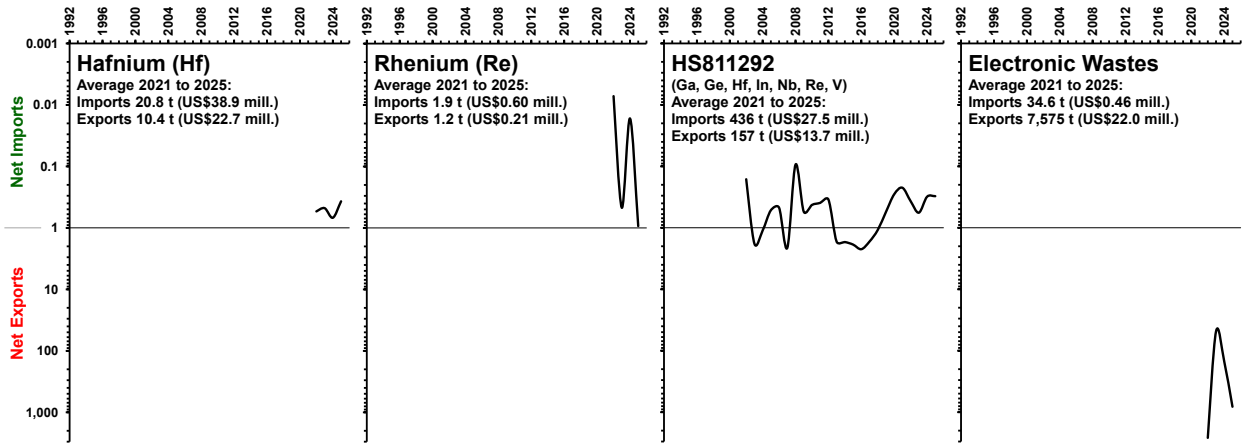


Figure 4 (continued) Export/import balance from 1993 to 2025, shown as exports/imports and including average values from 2021 to 2025. (Data from UN Comtrade). BGS © UKRI 2026.

4.2 COMPOSITION OF TYPICAL END-OF-LIFE WASTE AND MATERIALS

EoL waste is composed of highly concentrated urban ores that often yield higher concentrations of critical minerals than primary crustal abundance, as shown in **Table 3**. The critical mineral composition of this waste varies significantly depending on the type of waste stream and the size of EoL product. For example, a typical EV contains 2 kg of REE permanent magnets in its main traction motors, whereas a 3 MW wind turbine requires 2 t (World Bank Group, 2019; Edmondson, 2024). However, when this REE-containing material is estimated in waste streams, it accounts for less than 0.1 per cent of the entire weight of the product. This necessitates substantial deconstruction and sorting of individual components before cost-effective critical minerals recycling is feasible.

Global average ore or resource grades are also included in **Table 3**, based mainly on published global studies, internal mineral resources databases or commodity profiles. These data show that indicative recycling concentrations can sometimes be higher than those of primary mineral deposits (e.g., gallium, germanium, molybdenum), similar concentrations (e.g., chromium, cobalt, zinc) or where primary deposits have higher concentrations than recycling streams (e.g., manganese, nickel, niobium, strontium). It is important to note that site-specific techno-economic, policy and other factors may lead to higher or lower concentrations being viable for mining or recycling. All values are indicative only.

Table 2 UK imports and exports of key metal waste and scrap flows, rounded average from 2021 to 2025 and net flow direction based on mass / quantity. (Data from United Nations Department of Economic and Social Affairs (2026)) (cells shaded light blue show net exports whilst beige cells show net imports).

Commodity	Imports			Exports			Net flow
	tonnes (t)	US$ million	US$/t	tonnes (t)	US$ million	US$/t	
Aluminium [a]	101 513	165	1.63	606 561	1119	1845	Export
Antimony [b]	18.0	0.024	1335	6.37	0.054	8523	Import
Beryllium [c]	1.13	0.077	68 129	0.012	0.004	380 242	Import
Bismuth [d]	221	3.10	14 073	26.5	1.33	50 342	Import
Cadmium [e]	1.62	0.008	4752	0.062	0.003	50 676	Import
Chromium [f]	52.5	0.330	6333	304	2.25	7409	Export
Cobalt [g]	1205	19.8	16 462	788	17.9	22 687	Import
Copper [h]	25 508	148	5805	256 743	1634	6365	Export
e-Waste [i,#]	34.6	0.460	13 386	7575	21.9	2903	Export
Hafnium [j,#]	20.8	38.9	1 868 825	10.4	22.7	2 193 840	Import
HS811292 [k]	436	27.5	63 067	157	13.7	87 014	Import
Iron/steel [l]	294 895	147	498	7 938 274	3466	437	Export
Lead [m]	2577	5.08	1972	48 759	90.3	1851	Export
Magnesium [n]	93.8	0.160	1719	40 375	17.9	442	Export
Molybdenum [o]	1994	96.7	48 473	2620	89.8	34 267	Export
Nickel [p]	16 300	166	10 176	14 070	188	13 363	Import
Rhenium [q,#]	1.94	0.600	310 593	1.17	0.210	177 960	Import
Tantalum [r]	71.4	12.2	170 858	43.8	6.56	149 564	Import
Tin [s]	55.5	0.220	4010	1150	2.50	2175	Export
Titanium [t]	7281	32.6	4470	4918	32.8	6669	Import
Tungsten [u]	844	28.0	33 167	1527	27.3	17 909	Export
Zinc [v]	996	1.55	1562	4947	11.8	2387	Export
Zirconium [w]	85.5	1.13	13 201	76.6	2.11	27 543	Import

Notes: mill. = million. [a] HS Code 760200; [b] HS Code 811020; [c] HS Codes 811211, 811213; [d] HS Codes 810600, 810610, 810690; [e] HS Codes 810710, 810730; [f] HS Codes 811220, 811222; [g] HS Code 810530; [h] HS Code 740400; [i] HS Codes 854921, 854929 (these codes for precious metal recovery and printed circuit boards); [j] HS Code 811231; [k] Includes gallium, germanium, hafnium, indium , niobium, rhenium and vanadium; [l] HS Codes 720410, 720421, 720429, 720430, 720441, 720449, 720450; [m] HS Code 780200; [n] HS Code 810420; [o] HS Codes 810210, 810297; [p] HS Code 750300; [q] HS Code 811241; [r] HS Code 810330; [s] HS Code 800200; [t] HS Codes 810810, 810830; [u] Codes 810197, 810110; [v] HS Code 790200; [w] HS Codes 810910, 810930, 810931, 810939; [#] Only data for years 2022 to 2025.

Table 3 Indicative concentrations of metals or materials in selected EoL products (akin to a bill of materials), minimum concentration in the waste stream for sustainable and cost-effective recycling, average upper crustal abundance and indicative ore / resource grades for mineral deposits for comparison (cells shaded light green exceed the indicative recycling concentration). * indicates percentage; all other values are in parts per million.

Critical raw material	EV battery system (NMC) [1]	EV traction motors [2]	Wind turbines [3]	Solar photovoltaic modules (monocrystalline silicon) [4]	Smartphones [5]	Indicative concentration for recycling [6]	Upper crustal abundance [7]	Indicative global ore / resource grades [8]
Aluminium (Al) *	* 34.5	* 32.2	* 2.00	* 12.7	* 5.80	* >50.0	* 8.15	* 28
Barium (Ba)	-	-	-	-	3000	>100 000	628	53 000
Chromium (Cr)	-	-	-	-	180 000	>300 000	92.0	260 000
Copper (Cu)	92 000	103 000	10 000	13 000	58 000	>3000	28.0	4500
Cobalt (Co)	31 000	-	-	-	500	>2000	17.3	1600
Gallium (Ga)	-	-	-	-	80.0	>100	17.5	50
Germanium (Ge)	-	-	-	-	3.00	>100	1.4	~50
Gold (Au)	-	-	-	-	200	>1.00	0.002	0.41
Graphite (battery-grade) *	* 8.20	-	-	-	-	* >15.0	-	-
Indium (In)	-	-	-	-	23.0	>20.0	0.056	10
Iron (Fe)	-	-	* 10.8	-	* 13.9	* >20.0	* 3.92	* 47
Lead (Pb)	-	-	-	500	90.0	>40 000	17.0	4400
Lithium (Li)	10 000	-	-	-	8.00	>10 000	24.0	7000
Magnesium (Mg) *	-	-	-	-	* 7.10	-	* 1.50	* 22
Manganese (Mn)	28 000	-	-	-	2000	>300 000	774	480 000
Molybdenum (Mo)	-	-	-	-	300	>10 000	1.10	237
Nickel (Ni)	31 000	300	-	-	22 000	>50.0	47.0	8200
Neodymium (Nd) (REE magnets)	-	28 000	1000	-	2800	>100	27.0	823
Niobium (Nb)	-	-	-	-	40.0	>2000	12.0	6350
Palladium (Pd)	-	-	-	-	20.0	>0.200	0.001	1.01
Platinum (Pt)	-	-	-	-	4.00	>0.500	0.001	1.06

Critical raw material	EV battery system (NMC) [1]	EV traction motors [2]	Wind turbines [3]	Solar photovoltaic modules (monocrystalline silicon) [4]	Smartphones [5]	Indicative concentration for recycling [6]	Upper crustal abundance [7]	Indicative global ore / resource grades [8]
Silicon (Si) *	-	* 0.060	-	* 3.90	* 8.50	* >90.0	* 31.1	-
Silver (Ag)	-	-	-	700	100	>700	0.053	25
Strontium (Sr)	-	-	-	-	4000	>100 000	320	350 000
Tantalum (Ta)	-	-	-	-	400	>100	0.900	317
Tin (Sn)	-	-	-	900	6000	>1000	2.10	6330
Titanium (Ti) *	-	-	-	-	* 0.100	* >10.0	* 0.380	* 5.1
Tungsten (W)	-	-	-	-	2400	>500	1.90	13 600
Vanadium (V)	-	-	-	-	1000	>10 000	97.0	4130
Zinc (Zn)	-	200	-	-	5000	>10 000	67.0	12 000

Notes: -: no data; REE: rare earth element; NMC: lithium-ion rechargeable battery that uses a cathode made from a combination of nickel (N), manganese (M), and cobalt (C).

References: [1] Diekmann et al. (2017); [2] Pandey et al. (2025); [3] Moné et al. (2017); [4] Fraunhofer Institute for Solar Energy Systems (2026); [5] Bookhagen et al. (2020); [6] the indicative concentration for recycling is based on EU waste recycling / reprocessing operator estimates from Bergfald and Kristensen (2025) – technoeconomic recycling feasibility for specific wastes and sites may vary substantially, leading to higher or lower concentrations in different situations; [7] Rudnick and Gao (2014); [8] Aluminium, Germanium, Lithium, Magnesium, Molybdenum, Strontium – internal BGS databases; Barium – Johnson et al (2017); Chromium – Mosier et al (2012); Cobalt – Mudd et al (2013), Slack et al (2017), Petavratzi et al (2019); Copper – Mudd and Jowitt, 2018); Gallium – Butcher and Brown (2014), Melcher and Buchholz (2014), Foley (2017); Gold – Mudd and Jowitt (2018); Indium – Werner et al (2017); Iron – Government of Western Australia (2023); Lead-Zinc – Mudd et al (2017); Lithium – Mohr et al (2012), Evans (2014); Magnesium – Neelameggham and Brown (2014); Manganese – Cannon et al (2017); Nickel – Bide et al (2008), Mudd and Jowitt (2022); Neodymium – Weng et al (2015); Niobium, Tantalum – Orris and Grauch (2002), Shaw and Goodenough (2011), Linnen et al (2014); Palladium, Platinum – Mudd (2023); Silver – Singer (1995); Tin – Kamilli et al (2017); Titanium – Woodruff et al (2017), Perks and Mudd (2022), Huang et al (2023); Tungsten – Pitfield and Brown (2011), Werner et al (2014), Brown and Pitfield (2014); Vanadium – Kelley et al (2017).

4.3 UK DECARBONISATION FUTURE WASTE FLOWS

Recent CMIC research has assessed the likely future demands for critical minerals associated with decarbonisation technologies that could facilitate the UK economy achieving net zero greenhouse gas emissions by 2050. The work has focused on:

- photovoltaic (PV) panels (Petavratzi et al., 2024a)
- wind turbines (Petavratzi et al., 2024b)
- traction motors (Petavratzi et al., 2024c)
- EV batteries (Petavratzi et al., 2024d)
- electrolysers (Zils et al., 2024a)
- fuel cells (Zils et al., 2024b)
- heat pumps (Zils, et al. 2024c)
- nuclear power (Jackson et al., 2024a)
- electrical grid infrastructure (Jackson et al., 2024b)

A synthesis report combined all individual studies into a systematic assessment of all critical minerals and materials together (Petavratzi et al., 2024e).

This body of work has recently been updated and used to model the future flows of secondary materials from the EoL products from EV batteries, traction motors, solar PV panels and wind turbines (Petavratzi et al., 2026) to determine to what extent secondary supply from EoL products can meet future UK demands. We present a summary of this work as a case study in applying foresight modelling to future secondary material flows. The work adopts low transition (LT) and high transition (HT) scenarios to explore the pace of decarbonisation in the UK economy. Full details are available in Petavratzi et al. (2026).

In Figure 5, the UK demand associated with EV batteries for lithium and graphite is compared with future estimates for flows from secondary materials. The results show that substantive secondary flows do not emerge until the 2040s, with flows approaching close to UK primary demand by 2050.

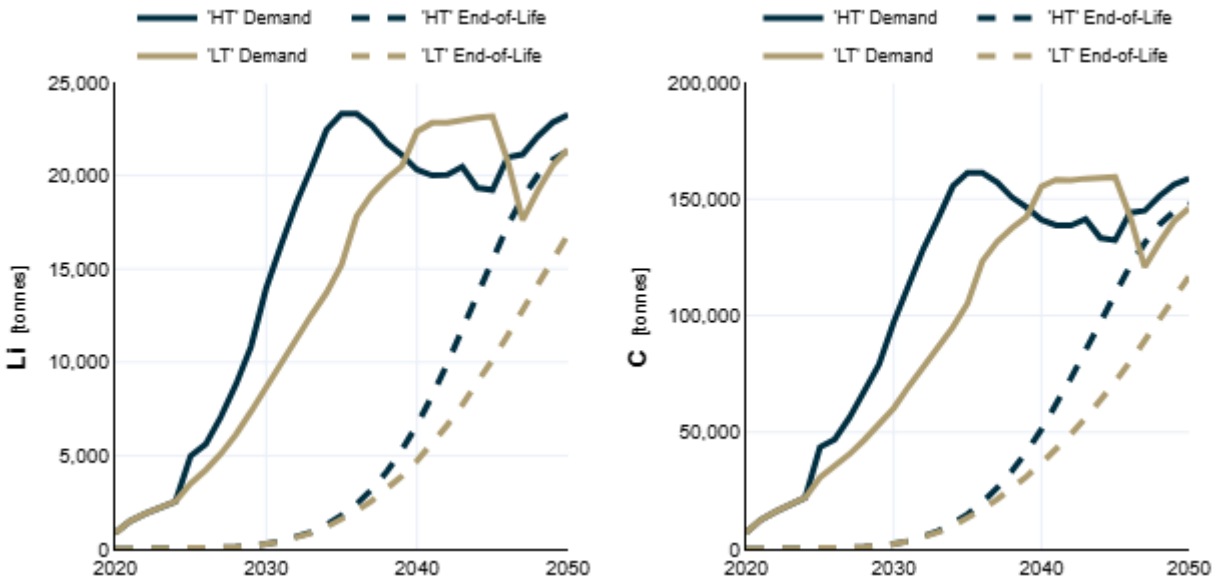


Figure 5 Annual demand (tonnes) and EoL quantities for lithium (Li; left) and graphite (as C; right) in EV batteries between 2020 and 2050 under the HT and LT pathways. BGS © UKRI 2026.

In Figure 6, the UK demand associated with traction motors for neodymium, dysprosium, boron and copper is compared with future estimates for flows from secondary materials. For each element, secondary flows in the LT scenario reaches UK primary demand by the mid-2040s, with the HT scenario exceeding UK primary demand by the early 2040s.

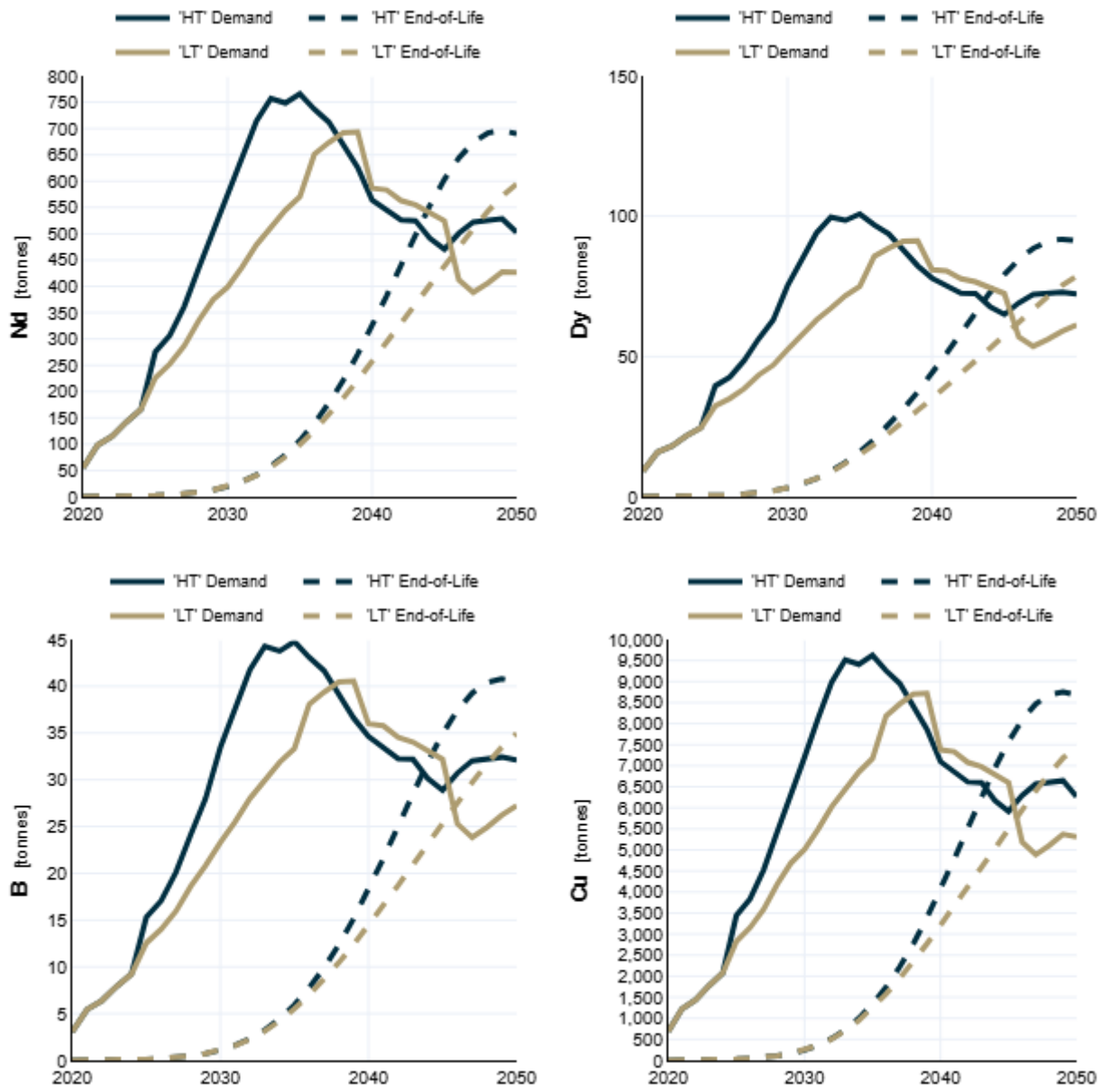


Figure 6 Annual demand (tonnes) and EoL quantities for neodymium (Nd; top left), dysprosium (Dy; top right), boron (B; bottom left) and copper (Cu; bottom right) in traction motors between 2020 and 2050 under the HT and LT pathways. BGS © UKRI 2026.

It should be noted that this assessment represents flows and does not account for collection and recovery losses. This means that primary supplies will remain important but secondary supplies will be able to improve UK supply-chain resilience, assuming these flows can be effectively captured and processed to provide the secondary supply this modelling suggests.

5 Stakeholder engagement

A key component of this project has been engagement with a range of operators across the waste management and recycling sectors. This was achieved via interviews using semi-structured questions and open discussion. This section summarises the key issues, common themes, challenges and opportunities that emerged from the interviews.

5.1 TARGETED FOCUS

A key point made by many stakeholders is that UK policy and efforts need to focus on what is relevant to both present and possible future UK markets. Although it is possible to establish certain recycling facilities, that does not mean that companies are present to purchase and use such recycled or secondary materials. For example, even if the UK recycled the black mass derived from EV batteries, there are currently no facilities that could use such material, with none likely in the near future based on present proposals and planning. This highlights the need for strategic policy and coordinated government–industry–community planning.

5.2 KNOWLEDGE AND EXPERTISE

The present and future availability of suitably qualified engineers, scientists and technicians is a universal concern for all stakeholders. There is currently a shortage of experts with metallurgical know-how to support recycling processes and businesses, and the situation is expected to worsen in the future, given the declining number of university graduates studying relevant subjects. Stakeholders reiterated the need to ensure there are fulfilling career paths in this area, as metallurgical skills and knowledge are absolutely fundamental in this field.

Some stakeholders also commented on the need to ensure that metallurgical skills and knowledge were complemented by business and commercial skills. In other words, recycling businesses need to translate metallurgical expertise into commercial advantage to ensure that the business case for recycling remains viable. This also emphasises the need for a range of skills covering economics, law, accounting and finance (amongst others), as well as strategic communication and outreach (for example, through corporate sustainability-style reporting).

Insufficient understanding of material complexity in products and technologies is a common challenge that can make recycling more difficult. This reinforces the need for greater skills and expertise in the underlying metallurgy of recycling.

5.3 TRANSPORT

The highly dispersed nature of EoL products and other waste materials means their collection and movement to sorting, separation or processing facilities will always involve significant transport logistics. While this already occurs, stakeholders noted the importance of approaching transport policy and regulation with a view to encouraging flows of waste materials and EoL products (rather than discouraging such flows). This was particularly relevant for export licensing, where smooth and predictable processes were crucial.

It is important to acknowledge the importance of material quality and effective regulatory oversight in maintaining confidence in UK exports. Concerns are noted across the sector around the quality of some material leaving UK ports, which can create environmental risks and potentially undermine confidence in legitimate recycling operations. That is, material composition and contamination can also influence how waste is classified for shipment purposes and how movements can take place. Consistency in how these requirements are interpreted and applied is therefore important, both for environmental protection and for legitimate international trade. This helps to achieve in practice the principle of ensuring that regulation supports legitimate material movements whilst mitigating poor practice.

5.4 CONTAINED VALUE AND LOSS OF MINOR METALS (DOWNCYCLING)

Alloys and superalloys may contain several elements that were brought together to achieve very specific characteristics, such as corrosion and heat resistance, density or weight (especially light weights) and strength. For example, superalloys used in jet turbines may be nickel-, copper- or aluminium-based but can also contain varying amounts of chromium, molybdenum, niobium, rhenium, tantalum, titanium, tungsten or vanadium, amongst others (Singh et al., 2023).

The value of all of these individual metals varies enormously, for example, in 2025 (United States Geological Survey, 2026; all values US dollars.):

- $300 to $400 per tonne for steel (iron)
- $15 000 per tonne for nickel
- $51 000 per tonne for molybdenum
- up to $2.6 million per tonne for rhenium
- $3.6 million per tonne for hafnium

Some stakeholders have noted that geopolitical tensions during 2026, especially export controls and tariffs, have seen the prices of many metals rise substantially, sometimes close to an order of magnitude higher (e.g., tungsten, rhenium, hafnium, and others to a lesser extent).

The contained value of all metals used in superalloys can therefore be substantial but superalloy waste containing nickel and other high-value elements, such as cobalt, hafnium, molybdenum or rhenium, may be directed to stainless-steel recycling (for example, to make rebar steel) based solely on its nickel content. This means that the high-value minor metals are effectively lost, including to future recycling efforts, and the high-value ferroalloy is recycled to a lower-value form. This outcome is known as ‘downcycling’.

At present, some alloy waste may be downcycled rather than being fully recycled for all of its valuable metal contents. One stakeholder noted that up to 90 per cent of the contained metal value could be lost during downcycling. Although it can be an economic approach to managing such waste flows, it is not ideal from a material flow, industrial system or whole-UK perspective: the high value of the minor metals is ignored and lost, requiring substantial efforts to replace these alloys from primary sources.

It was noted by various stakeholders that it is crucial to understand not only the value of metals within various wastes but also the costs of recycling to extract all of the contained metals. The business case needs to leverage the potential value of metals against the costs of recycling, leading to outcomes such as downcycling (since this can be the most economical option given the high costs of full recycling for all contained metals), partial extraction of selected metals (due mainly to their ease of recovery, such as copper, gold, palladium, aluminium), remelting where possible for new alloy manufacture or disposal when there is no other remaining viable option.

Stakeholders further noted that the influence of the regulatory framework on the commercial viability of recycling activities is important to understand. The classification of a material as waste does not itself prevent recovery, but the associated permitting requirements, authorised treatment activities, waste acceptance criteria (if destined for landfill) and the conditions under which recovered materials can achieve end-of-waste status can all influence costs and investment decisions. For emerging recovery technologies, particularly those targeting critical minerals, regulatory certainty and clarity around the status of recovered outputs can be important factors in determining whether a commercially viable recovery route can be established. Clear and proportionate regulation alongside consistent interpretation and timely regulatory decisions, can therefore play an important role in supporting investment and the wider ambitions of the Critical Minerals Strategy.

Overall, the issue of contained value is problematic, as value needs to be considered within the context of the costs of different recycling pathways and technologies. At present, although it may be technically possible to increase the recycling rates of superalloys (for example), it would invariably involve higher-cost technologies, which is one of the reasons they are not more widely utilised.

5.5 POLICY DEVELOPMENT

Various stakeholders raised concerns that policy can be developed without appropriate technical insight or sufficient understanding of both the capacity of current technological processes for recycling and the economics of the sector. This highlights the need for building and maintaining knowledge across both industry and government, especially the need for broad consultation when new policy developments are being proposed.

5.6 REGULATORY REGIME EVOLUTION

Several stakeholders noted their concerns about the need to evolve and modernise recycling regulations, especially making a clear distinction between waste classification and end-of-waste decisions. Some raised the point that, given the many forms of materials, metals or EoL products which are collected for recycling, recycling efficiency could be improved if they were not classified as waste. It was also noted that regulatory guidance lacks categories appropriate for waste metals. Addressing these aspects would reduce costs and help with the economics and speed of recycling. This also relates to concerns about the way that waste classification works and that the process needs to be improved. Regulatory consistency across various jurisdictions (for example, making sure that waste is classified the same way with identical outcomes across international, national and devolved jurisdictions) is especially needed. Alternatively, one stakeholder noted that the challenge isn't necessarily the classification of material as waste, but ensuring that the regulatory framework is proportionate, consistently applied and provides clear, workable routes for materials to achieve end-of-waste status.

Another important opportunity to improve recycling rates is evolving end-of-waste decision making. For example, after a recycling process has been completed, materials that were classified as waste should now be considered secondary resources suitable for use in manufacturing. Reclassification of waste to materials in this way should help improve the capacity for utilisation and therefore overall recycling rates. It was emphasised that this should not reduce the need for safe transport and management during all stages (including disposal where necessary). Furthermore, the completion of a recycling or recovery process does not automatically mean that a material has ceased to be waste. The relevant legal criteria still need to be satisfied, including whether the recovered material is suitable for its intended use and meets applicable technical and environmental requirements. As noted by stakeholders, there is a balance to be achieved between facilitating the movement of legitimate end-of-waste materials and ensuring appropriate safeguards against materials being incorrectly presented as having achieved end-of-waste status to avoid waste shipment controls.

5.7 LOWER EMISSIONS INTENSITY FOR RECYCLING

Stakeholders noted that recycling is generally considered less carbon-emission intensive than primary production. This means that more recycling will also help the UK move towards a net zero emissions economy, which is a key policy objective of the UK. Stakeholders also commented that only limited life-cycle assessment studies of recycling have been completed to date, meaning this remains an important area or opportunity for future research.

5.8 GREATER CIRCULARITY THINKING

Stakeholders universally argued the need for much greater circular thinking across the entire supply chain. Designs need to account for ways to improve product disassembly and component separation at EoL to make recovery and recycling easier. For example, separating the screen, battery, storage drive and main electronics board of a smartphone helps to deliver waste streams that are more easily recycled. The design phase should also consider the metals and materials used and their potential for recycling, adopting a design philosophy that chooses metals and materials that make recycling easier, thus avoiding the need to downcycle. This links back to the need for comprehensive knowledge of and skills in the material complexity of modern products and technologies, their associated EoL waste streams and the underlying metallurgy of their recycling.

All stakeholders noted the need for improved circular business models. This refers to ensuring viable processes for purchasing, processing and then selling EoL products and other waste, linking very closely to regulatory regimes around waste classification, transport, processing and end-of-waste decision making.

5.9 VOLATILE MARKETS

The prices of metals can go through periods of rapid change and volatility, which invariably translate into waste and scrap recycling markets (e.g., see the case of copper in Mudd et al, 2025). High volatility can make obtaining project financing difficult and increases the cost of normal business activities. Stakeholders recognised that this was a difficult area to address from a policy perspective, especially given the global nature of waste and scrap markets — and the UK's need to maintain interconnections with these markets — but stressed the importance of acknowledging the problem as a first step to explore potential policy measures in the future. Some stakeholders recognised that, while markets are important, they are not perfect and not all issues can be addressed, emphasising the need for active management and approaches that incentivise good outcomes for both businesses and the environment.

5.10 WASTE CONTENT DATA

A common challenge acknowledged by all stakeholders is current trade and economic data and statistics not tracking the metal contents of various EoL products and waste forms. For example, global trade data includes a quantity (or mass) for waste and scrap containing copper, but it does not include any data or information on the actual copper content. Based on typical copper uses and alloys, copper content can vary from 30 to greater than 99 per cent and may include a range of other metals, such as zinc or tin, or potential contaminants such as polymers and fibres (Mudd et al., 2025). For many ferroalloys, it would be important to track not only the content of iron but also all alloying elements such as cobalt, manganese, molybdenum, nickel, rhenium, titanium and vanadium, amongst others.

Better tracking of concentrations in trade and economic data would need to be updated regularly and cover millions of individual products and technologies (Table 3) and their derived waste forms. This scale of sampling and reporting is clearly unrealistic, especially given the constantly changing nature of the materials used in technological or product designs. Various stakeholders noted that understanding the contents of waste starts with the products themselves: having a bill of the materials used to make a product would significantly improve understanding of the EoL waste derived from that product. The principal example here is the EU's DPP proposal[22], which would contain design and material information for a given product throughout its life. The DPP will initially apply to EV batteries but will progressively expand to

[22] https://single-market-economy.ec.europa.eu/single-market/digital-product-passport_en

include iron and steel, textiles and eventually the broader range of smartphones, electronics, home appliances and many other technologies and products by 2029.

A crucial concern raised by stakeholders is that understanding (or predicting) metal content is a fundamental part of business strategy and success, as such understanding allows for better pricing and therefore sales and profitability. While content data can readily be aggregated to national levels, in much the same way that national economic statistics are currently synthesised by the Office for National Statistics, including when certain data is suppressed to protect commercial identities, in many cases the number of operators is small. This means that it could be possible to discern sensitive information and undercut the viability and profitability of recycling businesses.

Stakeholders agreed that metal content data and information would be useful, but careful consideration of risks to existing businesses, alongside consideration of how such data can be used and misused, is needed. This requires substantial further research to explore and develop potential approaches.

5.11 CONTAMINANTS

A variety of materials can make recycling more difficult or preclude some forms of waste entirely from being able to be recycled. Such materials are known as contaminants and may include chemicals, food scraps, plastics or polymers, fibres and other, non-target metals, which may all make recycling of the primary metal more expensive and uneconomic. This highlights the need for efficient collection, separation and processing technologies, incorporating consumer and industry education on the need to minimise contaminants during recycling as well as reinforcing the role that better design can play in reducing risk.

5.12 RECYCLING AS A HIGH-VALUE SERVICE

Many stakeholders noted that recycling was a high-value service to society that could be recognised in many ways. For example, recycling could be seen as an ethical process, since it helps to reduce environmental and social impacts associated with resource use; similar to ethically sourced foods, recycled materials should be seen as ethical and helps to improve the sustainability and responsibility of supply chains. As noted previously, the typically lower carbon intensity of recycled materials can also make a strong contribution to a recycled material's value proposition to a society working towards a net zero economy, thereby improving its ethical standing.

An important but perhaps underexplored area is that of consumer preferences. There are various examples of goods where consumers have shown increasing preferences for ethically sourced products (for example, food; paper; renewable energy), but this has not translated through to the same extent to the metals and materials used in complex technologies such as smartphones and computers. Perhaps the best example of a product that exemplifies the value in promoting recycled material content is the Fairphone. This smartphone product has been designed to facilitate easy component replacement (for example, replacing an ailing battery or broken screen) as well as aiming for high rates of recycled contents in its manufacture[23], both key elements of improving circularity in products by design and intent. The Fairphone case also highlights the role that consumer choice can play in promoting recycling and capturing business share.

Stakeholders again noted that recycling value also needs to be tempered with the commercial reality of current and likely future costs and available technologies for recycling of different EoL products and their waste streams. They also stated that recycling should be viewed as part of

[23] https://www.fairphone.com/hub/en/impact/fair-materials/

national resilience and material sovereignty or independence (notwithstanding the need for primary material inputs). This was agreed as a key part of the policy foundation of Vision 2035 but perhaps greater emphasis on it could be useful in justifying the value proposition of recycling.

Stakeholders acknowledged that key drivers for improving recycling value are legal requirements and education (of both industry and consumers) as well as appropriate pricing and policy leadership.

5.13 LACK OF UK PROCESSING FACILITIES

In general, there are very few UK processing facilities for recycling the many and varied EoL and other waste streams (for example, electronic waste is exported; see Table 2 and Figure 4). This limits the capacity to reprocess materials and waste in the UK and requires operators to export such forms internationally. This also reinforces the need to plan such international connections, especially as it may make more logistical and economic sense to locate particular facilities in some countries. The UK could be a partner in such a venture.

As one stakeholder noted, given the need for international networks across supply chains to support waste collection, separation and reprocessing, critical minerals recycling policy also needs international partnerships and leadership, which they felt was lacking at present (that is, it is a weakness of Vision 2035).

5.14 STOCKS AND FLOWS

As explored in Section 2 and shown in Figure 2 and Figure 3, understanding the flows of materials or resources within an economy is important, especially the buildup of stocks in different uses and their eventual release as EoL products and waste. This type of assessment is known as material flow analysis (MFA) and can be conducted for a single year (known as a static MFA) or accumulated over a long time period (dynamic MFA). MFAs can be used to help quantify residence times for different resource uses; for example, steel in cars versus steel in construction or home appliances. Very few MFA studies exist for the UK, however, leaving a major gap in our understanding of the stocks across the UK for most critical minerals and their likely flows through to EoL products and waste forms.

Recent CMIC research on using future demand for critical minerals in decarbonisation technologies is analogous to dynamic MFA (see section 4.3), noting it models forwards rather than synthesising historic data. There is a clear need to conduct MFAs for many minerals in active use in the UK, noting that each mineral assessed would itself be a major research project, leading to better quantification of stocks and flows and understanding of residence times, and the ability to predict future secondary flows. The final choice of which minerals to prioritise for MFAs would need to consider relevant policy needs, industry concerns, data availability and the potential to improve recycling rates.

5.15 HIGH ENERGY COSTS

Given that recycling is energy intensive, albeit typically lower per tonne of metal than primary production, the relatively higher cost of energy for the UK compared to our international counterparts presents a substantive barrier to the business case for specialist recycling facilities in the UK. This was an issue of universal concern for stakeholders.

5.16 SUPPLY-CHAIN NETWORKS

Stakeholders noted that understanding individual supply-chain networks was a crucial part of business intelligence and competitiveness, especially as it relates to material forms and contents, as well as helping to ensure predictable costs and potential revenues. The role of government here can be through matchmaking to improve business connectivity across complex supply chains both nationally and internationally.

5.17 OPEN FLOWS THROUGH IMPORTS AND EXPORTS

All stakeholders strongly supported the proposition that the UK needs to be open to the import and export of waste into and out of its economy. This means that the UK needs to maintain its alignment with international best practice (such as that in the EU) in waste classification, transport and processing, especially given the minimal number of specialist reprocessing facilities in the UK. Future research could investigate how the synchronisation of waste classification codes with trade (harmonised system or HS) codes, especially as they relate to different recycling and manufacturing facilities in the UK or EU (or elsewhere).

Stakeholders reiterated the need to work with trusted partners (for example, the EU) and ensure harmonisation of regulatory approaches, especially for waste classification, transport, reprocessing and end-of-waste decision-making. Working with trusted partners improves the responsibility of the supply chain and therefore industry and consumer confidence in the recycle sector and the secondary materials it produces.

As one stakeholder noted, recycling doesn’t work with extreme protectionism — waste bans typically cause major supply-chain damage as well as substantive commercial pressures. It was further noted that, even after allowing for domestic production of some critical minerals, recycling will invariably fail to maintain its business case if the UK is isolated from international supply-chain networks, such as those for lithium, platinum group elements and tungsten, amongst others.

6 Summary: key findings, challenges and opportunities

6.1 KEY FINDINGS

This study reviewed the approach to waste classification in the UK at a high or conceptual level, focusing on EoL products, manufacturing waste and industrial waste streams. It reviewed the systems thinking behind current practices and places them in the context of the current challenges of recycling and the ambition for the UK to improve its recycling rates for critical minerals. Improving recycling rates can help to improve UK resource efficiency and supply-chain resilience as well as reducing overall environmental impacts of resource use.

A brief review of the UK's regulatory approach highlights key similarities and some differences to the EU and other economies facing the same challenges. The current regime is effectively based on a linear approach to resource extraction, use and disposal, with modern evolution to facilitate recycling to the extent possible.

Three examples were developed that highlight the following points.

- Balance of imports and exports:
  - analyses of imports and exports for the UK show net exports over 2021 to 2025 for widely used metals such as aluminium, chromium, copper, iron, lead, molybdenum, tin, tungsten and zinc as well as electronic waste (noting some are substantial net exports while others are somewhat minor)
  - longer-term trends highlight the importance of rapid changes in the shift between net imports to exports (e.g., magnesium, see Figure 4)
  - net exports are largely driven by the lack of specialist recycling processing facilities (noting stakeholder concerns on the high costs of energy being a barrier to such facilities in the UK)
  - net imports would appear to be related to specialty alloys using minor elements in the aerospace and automotive sectors
- Metal contents in EoL products:
  - concentrations of some critical minerals within EoL products can be significant and higher than the indicative minimum concentrations needed for recycling
  - it is important to note that some products are installed in the hundreds or thousands (for example, wind turbines) with large quantities per site, whereas other products (for example, smartphones) with high concentrations but low amounts per device may count in the millions but are highly geographically dispersed
- Future secondary flows from principal decarbonisation technologies:
  - assuming that the UK further develops infrastructure and policies to support battery and magnet recycling
  - key elements such as lithium and cobalt could come close to supplying UK demand for EV batteries by 2050, needing minor supply from primary sources
  - secondary material flows for the key REEs used in permanent magnets within traction motors (used in wind turbines and EVs) could meet primary UK demand by 2050
  - research highlights the importance of developing models of resource flows to inform policy, technology and infrastructure requirements for recycling and the circular economy

The following key issues were identified through stakeholder engagement (noting that they are not presented in any order of priority):

- Knowledge and expertise: maintaining the skills and expertise remains key to recycling efforts, from both technical and business perspectives
- Transport: this remains a fundamentally important area to facilitate improved recycling rates (especially given the geographically dispersed nature of many EoL products and waste)
- Contained value and downcycling: high-value metals can be lost due to downcycling of superalloys, highlighting the tension between technology, economics and policy ambitions
- Policy development: there is a need to ensure that policy is developed in concert with relevant expertise, especially concerning the metallurgical processes involved in recycling
- Regulatory improvements: ideas such as evolving waste classification in the first instance and end-of-waste decision making could help improve the competitiveness of recycling
- Lower carbon intensity: the typically lower greenhouse gas (or carbon) emissions from recycling over primary supply is a significant benefit of recycling
- Circularity approaches: the need for greater emphasis on recyclability during product design, as well as improvements to circular business models
- Volatile markets: rapid price changes hamper business predictability and investment appetite (although there are no easy fixes to this, given the global nature of most waste and scrap markets)
- Metal contents: while such intelligence and data are recognised as valuable, they typically form the business advantage for many recycling operators; possible solutions exist but are impractical at the scale of the UK economy for all products and technologies
- Recycling as a high-value service: the process of recycling can be considered an ethical imperative for a responsible and resilient supply chain, as well as meeting increasing consumer preferences for such products and contributing to national supply-chain or resource resilience
- Lack of UK reprocessing facilities: the minimal extent of UK facilities means that many EoL products and associated waste need to be exported, making it more difficult to achieve greater recycling rates within the UK (which also highlights the crucial importance of international partnerships and leadership in critical minerals recycling as part of broader UK strategy and policy)
- Stocks and flows: there are minimal MFAs for the UK economy, especially comprehensive dynamic MFAs that facilitate better understanding of the quantities of built-up stocks and residence times amongst particular uses
- High energy costs: these remain a substantive barrier to greater recycling
- Open UK economy: it is crucial to maintain the ability to import and export waste

6.2 POLICY RELEVANCE AND OPPORTUNITIES

Currently there is no singular UK policy document that has critical mineral waste flows at its heart; however, the topic does cross-cut several major policy priorities in the UK and devolved nations, for example:

- UK Critical Imports and Supply Chains Strategy (Department for Business and Trade, 2024)
- Vision 2035: Critical Minerals Strategy (Department for Business and Trade, 2025)
- Net Zero (HM Government, 2022)
- Modern Industrial Strategy (HM Government, 2025)
- National Planning Policy Framework (Chapter 11) (Ministry of Housing Communities and Local Government, 2026)

Understanding these waste flows also contributes to other policy initiatives, such as:

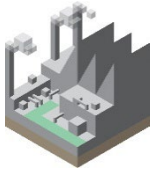
- the 25-year Environmental Improvement Plan (Department for Environment Food & Rural Affairs, 2025)
- Delivering 30by30 (Department for Environment Food & Rural Affairs, 2026)
- simpler recycling reforms
- regulatory requirements such as the Extended Producer Responsibility for Packaging and Regulating Product Sustainability (e.g., POST, 2021)

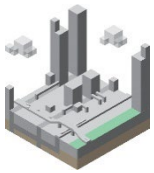
Collectively, current UK policies directly or indirectly identify a clear need to understand critical mineral waste flows to quantify their socio-economic benefits, support evidence-based decision making and strengthen the UK's resource security and economic resilience. Table 4 demonstrates the diverse sectors in which waste classification data and knowledge will make an impact, together with relevant UK policies and strategies.

Looking internationally can help identify different approaches to policy. For example, Japan's classification of incinerated waste as 'thermal recycling', where wastes are combusted to generate heat and/or electricity and not primarily recovery of metals or minerals, has made material recycling rates look higher than they actually are[24]. Japan recently published an update to its 'Act on the Promotion of Effective Utilization of Resources'[25] aiming to rectify this. In the Netherlands, the National Waste Management Plan was replaced with a Circular Materials Plan[26], which focuses on classifying EoL products in terms of raw materials instead of waste, utilising the 'urban mine' (van der Voet et al., 2025).

[24] https://japan-forward.com/japans-plastic-recycling-the-unseen-reality/
[25] https://www.meti.go.jp/english/press/2025/0225_001.html
[26] https://circulairmaterialenplan.nl/

Table 4 Synthesis of key economic sectors and relevant policies.

Sector	Aim	Policies
Net zero 	Ambitious recovery and recycling rates can contribute towards UK net zero targets and industrial strategy goals, keeping critical minerals in circulation for longer and helping to lower the overall environmental footprint of associated activities.	Net Zero Strategy UK Modern Industrial Strategy Resources and Efficiency Strategy Resources and Waste, Clean Energy Extended Producer Responsibility for Packaging Regulating Product Sustainability
Domestic supply 	Detailed planning and strategic investment in domestic supply potential and resource recovery e.g. for critical infrastructure, defence, energy and industry. Subsequently reducing dependence on imported raw materials/minerals and improving supply-chain resilience avoiding disruptions caused by geopolitical tensions, trade restrictions or market volatility.	Resources and Efficiency Strategy Resources and Waste Strategy for England (2018) UK's Modern Industrial Strategy British Industrial Competitiveness Scheme (BICS) UK Critical Minerals Strategy (Vision 2035)
Industry 	Sector priorities to create potential employment and industrial opportunities in, for example, engineering, geoscience, manufacturing and environmental services and creating skilled jobs in collection, sorting, processing and manufacturing.	Vision 2035: Critical Minerals Strategy UK's Modern Industrial Strategy Jobs and skills for a circular economy (IChemE, IOM3 and RSC report)
Economy 	Contributing to regional economic development, particularly in areas with existing industrial and mineral-processing capabilities.	UK Modern Industrial Strategy Industrial Strategy Zones Action Plan

Sector	Aim	Policies
Investment 	Strategic investment in domestic recycling/processing capability and capacity. Streamline infrastructure requirements such as resource recovery facilities and advanced processing plants.	UK Modern Industrial Strategy Scottish Programme for Government 2025 to 2026 Zero Waste's Scotland Delivery Plan 2025 to 2026 Resources and Waste Strategy for England (2018)
Responsibility 	Identifying requirement for regulatory regimes and import-export waste flows. Producer responsibility scheme updates to enable identification of waste streams containing strategically important materials and potential contaminants to allow for appropriate permitting.	Environmental protection Act 1990 (Duty of Care Requirements) Waste Duty of Care Code of Practice Waste Carrier, Broker and Dealer regulations Hazardous Waste Regulations (where applicable)
International 	Identify opportunities for creating and developing international partnerships.	UK Critical Imports and Supply Chains Strategy (2024) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

6.3 KEY OPPORTUNITIES AND RECOMMENDATIONS

This report highlights many opportunities and requirements for improving the circularity of the UK economy. Its recommendations are:

- future work should explore possible methods for better understanding of the metal contents of waste flows in the UK, including ways that the data can be aggregated and made available while protecting the commercial needs of the recycling sector
- review the processes and guidance for the classification of waste at the start of the recycling process as well as the end-of-waste assessment, with a view to improving the way that recycling can be further enhanced in the UK
- explore ways to support the development of comprehensive dynamic MFAs for key metals in the UK economy, such as copper, iron/steel, nickel and others, which should aim to quantify stocks and flows in the UK to support future increases in recycling rates
- ensure UK recycling and circular economy policies reflect the high-value service that recycling provides
- provide international leadership around critical minerals in recycling and circular economies (focus includes more than primary production)
- support the continued investment into skills and expertise to strengthen the UK recycling and circular economy sectors, which should reflect not only the need for metallurgical and related expertise but also the commercial and policy needs of the sector

Abbreviations and acronyms

BGS	British Geological Survey
CMIC	Critical Minerals Intelligence Centre
CRM	Critical raw material
CRMA	Critical Raw Materials Act (European Union)
DPP	Digital product passport
EA	Environment Agency
EGD	European Green Deal 2019
ELV	End-of-life vehicle
EoL	End-of-life
EPR	Extended producer responsibility
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
EV	Electric vehicle
HT	High transition (climate change scenario pathway)
LT	Low transition (climate change scenario pathway)
MFA	Material flow analysis
PGEs	Platinum group elements
PV	Photovoltaic
REEs	Rare earth elements
SEPA	Scottish Environment Protection Agency
UN	United Nations
UNFC	United Nations Framework Classification
WAC	Waste acceptance criteria
WEEE	Waste electrical and electronic equipment

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