POLICY BRIEF

Critical minerals in the UK: *Insights* from the analysis of 10 Net Zero Pathways

PUBLISHED

ENGINEERING, UNIVERSITY OF CAMBRIDGE, CAMBRIDGE, UNITED KINGDOM

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PLEASE CITE AS: STEPHENSON, S., CULLEN, J.M. AND CABRERA SERRENHO, A. (2026). CRITICAL MINERALS IN THE UK: INSIGHTS FROM THE ANALYSIS OF 10 NET ZERO PATHWAYS. POLICY BRIEF. UNIVERSITY OF CAMBRIDGE. HTTPS://DOI.ORG/10.17863/CAM.128454

DOI: 10.17863/CAM.128454

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RESEARCH IN THIS REPORT IS FUNDED BY CCG, CLIMATE COMPATIBLE GROWTH: HTTPS://CLIMATECOMPATIBLEGROWTH.COM/ABOUT-US/

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EXECUTIVE SUMMARY

The 2025 UK Critical Mineral Strategy [1] sets out new targets to grow domestic critical mineral extraction and recycling capacity, and diversify supply chains, to support UK manufacturing. However, manufacturing is not the only way minerals enter the UK, the UK also imports significant quantities of critical minerals embodied in end use technologies (like electric vehicles). Ensuring mineral supply for manufacturing, and imports, is important for decarbonization and economic growth.

Net zero pathways offer one way to gain insight into the combined future demand, detailing which technologies will be required and when. Translating these pathways into material requirements allows for informed strategic planning and policymaking. Below, we set out insights and policy recommendations to support the UK Critical Mineral Strategy. Given the lack of domestic mineral reserves, the recommendations focus on delivering supply through recycling. Our analysis suggests 2035 mineral recycling targets are unlikely to be met (due to limited end of life technology), however, by 2050, recycling could meet the majority of the UK's total demand for minerals. To deliver this, and ensure long term economic and energy security, the UK needs to invest in growing the battery recycling sector. One way to do this is a critical mineral stockpile, filled via strategic offtake agreements with critical mineral recycling that takes place in the UK. This needs to be accompanied by wider investments in manufacturing to ensure there is domestic demand for recycled materials. This includes investment and support for intermediate products in clean energy supply chains, for example battery component manufacturing which recycled critical minerals feed directly into.

Key Policy Recommendations

→ Support the development and expansion of a critical mineral recycling industry to harness minerals in technologies at the end of their life through guaranteed procurement.

→ Invest in infrastructure to reduce energy (and mineral) demand over the long term to increase energy security and resilience.

→ Accelerate green technology uptake by shifting the burden of taxation away from electricity and onto fossil fuels and additional incentive for green technology users (for example preferential lane access on roads).

Introduction

Governments across the world are scrambling to secure supplies of critical minerals. The centrality of rare earth metals in the USA - China trade deal [2], and large investment deals including EUR2.5 billion investment by the EU in Central Asia to ensure access to critical minerals [3] highlights that countries are increasingly aware of the importance of securing access to these minerals, for both decarbonisation and economic growth. However, how much and when these minerals will be required remains a key uncertainty. Demand for critical minerals within these clean energy technologies will depend on how countries decarbonise. Choices over clean energy technologies, for example, electrification of household heating vs. the use of clean hydrogen will depend on the price of different technologies, government policy and deployment, while the public's willingness to accept change or disruption in their lives will also impact what type of changes take place.

Despite this uncertainty in how decarbonisation will unfold, insights into potential futures are important as they allow for better planning to meet these changes, including ensuring that the UK has sufficient access to critical minerals to meet future demand. One way to gain insight into when these minerals will be in demand is through the analysis of net zero pathways. Many pathways provide suggested deployment routes for clean energy technologies, telling us how much and when different technologies need to be deployed in order to meet the UK's legally binding emissions reduction targets. These insights can in turn be used to understand how much and when different critical minerals will be in demand.

An important first step for the UK is to understand which minerals are required, when they will be required, and when they will be available for recycling. Based on findings from a recent paper to answer these questions [4], we present some policy recommendations that are designed to ensure the UK has a resilient supply to these critical minerals over the next 30 years.

Background and Context

The UK recognises that availability of certain minerals are important for the UK's economy and designates them as 'critical'. Analysis of which minerals are critical for the UK is informed by work from the British Geological Survey's 2024 Criticality Assessment [5]. Based on this, the newly released UK Critical Mineral Strategy [1] sets out a vision for what UK critical mineral supply chains will look like in 2035. This includes:

- 10% of critical mineral demand to come from domestic sources;
- 20% of critical mineral demand to be met through recycling;
- No more than 60% of mineral demand for each mineral to be met by a single country.

To meet these targets and design effective policies, the government needs a clear picture of future demand for critical minerals. Reaching these goals will involve trade-offs. For example, supporting UK manufacturing of lithium iron phosphate (LFP) batteries could create demand for lithium produced in Cornwall and reduce the country's reliance on cobalt by moving away from nickel–manganese–cobalt (NMC) batteries. However, this shift would also create challenges for battery recycling. Most recycling facilities today are designed to recover cobalt from NMC batteries using relatively low-cost processes. LFP batteries do not contain cobalt, and recovering lithium is more expensive. Under current market conditions, this makes LFP recycling less financially attractive [6]. To make large-scale LFP recycling viable, either lithium prices would need to rise or the government would need to provide targeted support.

The latest analysis within the Critical Mineral Strategy focuses on mineral demand for manufacturing in the UK. However, it does not consider the total mineral demand embodied in technologies used in the UK, despite the fact that the majority of clean energy technologies are imported, and the UK does not have the manufacturing capacity to produce clean technology components domestically. Even if domestic manufacturing increases, it remains unlikely that there will be sufficient Electric Vehicle (EV) battery manufacturing to meet vehicle demand [7]. Given this, the largest source of critical minerals and EV batteries is likely to come from battery recycling.

Projections of total future demand (from domestic manufacturing and imports) can therefore inform the availability to critical minerals that can be extracted from products reaching their end of life. Critically, if we want to meet the future target of 20% of demand met through recycling, then sufficient new technology needs to be deployed today in order to be available for recycling in the future.

In order to understand the requirements for the recycling target to be met, we examine the critical mineral demand associated with 10 net zero pathways produced by three organisations: 1. the National Energy System Operator, 2. The Climate Change Committee and 3. The Centre for Research into Energy Demand Solutions (see Appendix 1 for a full list of the different pathways included in the analysis).

Beyond the critical mineral demand from the energy transition, future mineral demand will also depend on the economic activities of a number of other sectors including aerospace and defence. Future demand for these sectors is much more uncertain and likely to depend on a range of market and geopolitical forces. Understanding future demand for these sectors is also important for the government, though not informed by net zero pathways.

Findings and new insights

Policy recommendations made below are based on the analysis of three critical minerals essential for the production of batteries, including in EVs: cobalt, graphite and lithium. Using a stock-flow model, the results show the annual demand for 3 critical minerals in technologies entering use each year, and the amount of critical minerals embodied in technologies reaching their end of life. Demand projections account for the total critical mineral demand in clean energy technologies deployed in the UK, not just those produced domestically.

Moreover, the exact amount of critical minerals that can be extracted from technologies and recycled to be used in new technologies depends on the choice of recycling technology. The findings show that there is likely to be limited embodied stock of critical minerals in technologies reaching end of life between 2030 and 2035 to meet the UK's 2035 recycling target. This is due to the lifetime of clean energy technologies and that clean energy deployment was still in its infancy between 2015 and 2020 [8]. However, the results do show that the amount of cobalt, graphite and lithium in end of life technologies is expected to increase significantly after 2040. By 2045 we find that there is sufficient minerals in technologies reaching their end of life to provide between 70-100% of new mineral demand for all technologies in use in the UK (in net zero scenarios). However, delivering this depends on improvements in battery recycling technology and the deployment of sufficient recycling capacity in the intervening period.

Furthermore, the findings show that accelerated deployment over the next 10 years (as seen in the shift and transform scenarios) leads to greater availability of minerals in technologies reaching end of life after 2040. This would increase the amount of future critical mineral demand that could be met through recycling, given that future recycling rates will be less than 100%

In summary, we find that there is unlikely to be sufficient domestic supply of clean energy technologies reaching their end of life to deliver on the UK's 2035 target. However, critical minerals in technologies reaching their end of life after 2040 means that there is a possibility that the UK could meet the entirety of its end-use demand for cobalt, graphite and lithium from clean energy technologies (not just demand from production) from recycling, depending on recycling rates.

FIGURE 1

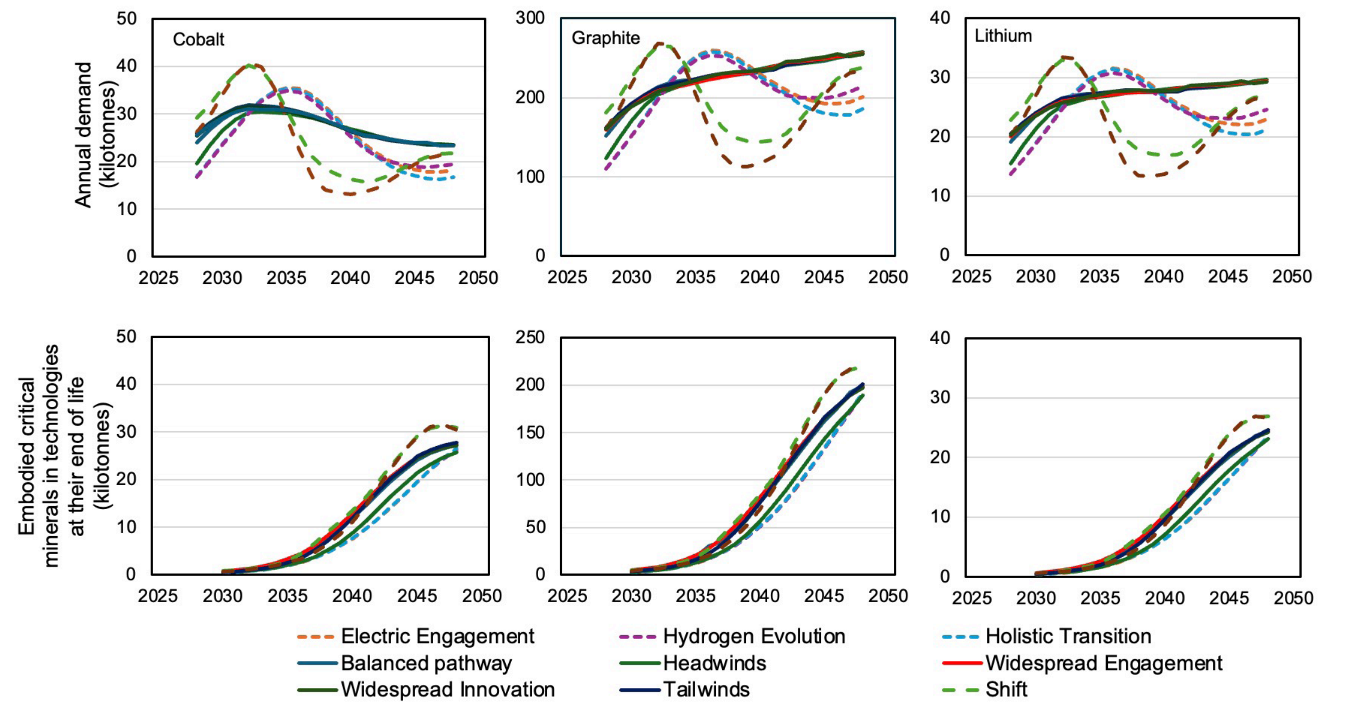

FIGURE 1: ANNUAL DEMAND FOR COBALT, GRAPHITE AND LITHIUM IN CLEAN TECHNOLOGIES IN THE UK (TOP ROW) AND THE AMOUNT OF COBALT, GRAPHITE AND LITHIUM IN CLEAN TECHNOLOGIES REACHING THE END OF THEIR LIFE EACH YEAR (BOTTOM ROW). TABLE 2 IN APPENDIX 2 GIVEN A BREAKDOWN OF MATERIAL INTENSITY OF ENERGY AND TRANSPORT TECHNOLOGIES THAT CONTRIBUTE TO MINERAL DEMAND AND END OF LIFE AVAILABILITY.

Policy Recommendations

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Based on these demand projections, the policy recommendations are centred around 3 themes: supporting creation of industries that can harness the domestic supply of critical minerals in green technologies at the end of their life; driving faster deployment of clean energy technologies; creating the infrastructure to reduce energy demand over the long term.

1. Supporting creation of a critical mineral recycling industry that can harness the domestic supply of critical minerals in green technologies at the end of their life

The UK possesses limited domestic reserves of the critical minerals that will underpin the green transition, and has not sought to actively develop a critical minerals industry. Creating new industries around processing would not align with decarbonisation targets (due to the time taken to develop these industries) and provide little value add to the economy [9]. Instead, the UK should take advantage of falling clean energy technologies globally over the short term and develop a recycling industry centred around the expected domestic supply of critical minerals from end of life technologies. Government support (i.e., investment or procurement contracts) is required, given the long timeline associated with developing these industries and the uncertain future availability from end of life technologies.

The UK government could guarantee the purchase of all critical minerals produced by recycling products in the UK to create critical mineral stockpiles. Such strategic offtake agreements are already being pursued, for example by Japan [10], to reduce their dependency on China. Over the long term this could be cost neutral as the government sells stockpiled minerals when required. This would have the dual benefit of ensuring that critical mineral recycling companies always have a buyer, therefore increasing likely investment, and reducing dependence on unreliable international actors for minerals that are critical to the UK economy.

This government action needs to be supported by wider investment in clean energy supply chains (including intermediate products) to ensure domestic demand for recycled critical minerals. Without all steps of the supply chains, recycling cannot help improve the UK's energy and economic resilience.

2. Support faster deployment of clean energy technologies

While the government has been committed to deploying clean energy technologies, greater policy action is needed to overcome remaining barriers, and make clean energy technologies, like EVs, more cost competitive. In Norway, EVs receive a 50% reduction in road taxes, and electricity for EV charging is not taxed, unlike petrol [11]. As a result, all new vehicles in Norway are now electric [11]. China has also introduced a range of policies to make it cheaper and preferable, (for example preferential lane access on road) [12] resulting in an EV market share for new vehicles over 50% [13]. In contrast, EV sales still remains at 25% of market share in the UK [8].

The UK should shift the burden of taxation away from electricity and onto fossil fuels, both for heating and transport, by removing the climate change levy on electricity use by businesses and increasing fuel duty. This would incentivize the use of electric vehicles over petrol and diesel cars. Fuel duty has been frozen since 2011, leading to road transport emissions being 24% higher than if the tax had risen with inflation, moreover, a proposed temporary cut to fuel duty has also been extended annually since 2022 [14] To mitigate concerns over increasing the cost on consumers, taxes on electricity consumption could be reduced to further incentivise electrification and make EV charging more attractive than driving an internal combustion engine powered car.

3. Creating the infrastructure for reducing energy demand over the long term

Infrastructure investments that reduce long term energy demand without sacrificing economic activity or social welfare should be prioritised as a way to reduce our dependence on overseas critical mineral suppliers. To begin, policies should target greater use of public transport (where ticket prices have increased at above inflation rates, unlike fuel duty). Long distance rail tickets, for example, have increased twice as fast as CPI since 1990 [15].

The government currently caps the price of certain regulated fares on trains. They should use this power to bring down the cost of train travel over time (relative to other forms of travel), moving beyond the budget announcement in November 2025 to not raise rail fares, and actively reduce the cost of tickets. We have seen that reducing fare prices leads to an increase in public transport use. Following the introduction of the £2 bus fare cap in 2023, bus use rose by 5% [16].

Implementation Considerations

The fiscal constraints of the government and the cost of living burden felt by the public remain top priorities for the government. Given this, consideration has been given to recommending policies that do not significantly impact the government's day to day budget and do not increase the financial burden on people. The policy recommendations focus on refocusing existing taxes to drive behaviour change rather than creating new taxes and introducing new subsidies which stimulate activity (for example increased public transport use acts as an economic multiplier [17]).

The UK has committed to the twin challenges of decarbonisation and growing the UK economy (see the Carbon budget and growth delivery policy paper [18]). This can be achieved through the development of domestic clean technology industries. However, the timelines for developing these industries and the clean technology deployment needed to meet UK targets do not align. Given this, the UK should seek to accelerate technology deployment in the short term, in order to secure supply before global demand significantly expands. It can then introduce long term plans to secure a domestic supply of critical minerals through recycling clean energy technologies that can support future economic growth.

Previous work has shown how reaching net zero can deliver growth and prosperity for the UK [19]. Knowledge and management of the UK's future demand for critical minerals is essential to unlocking this. Moreover, faster deployment of clean energy technology does not necessarily increase the aggregate demand for critical minerals and can lead to a more efficient and productive economy. Based on this, developing a domestic critical minerals supply chain based on recycling can ensure continued access to the minerals the economy needs to continue to grow in the future.

Conclusion

Knowing how much critical minerals are required and when they will be needed is a vital part of ensuring economic security and development. In the absence of (existing) domestic extraction of critical minerals in the UK, the UK should seek to accelerate the energy transition in the short term, to minimise potential future disruption, and use that to build a future supply chain based on domestic recycling. There are fiscally neutral policies that can achieve this, such as rebalancing the taxation between electricity and fossil fuels, including fuel duty.

Moreover, the UK can support the growth of new industries in the clean economy by developing stockpiles of critical minerals and signing strategic offtake agreements with new industries. Many countries are already acting to capture minerals critical to the economy of the future. In the UK, more policy action is required to accelerate the green transition and ensure our own supply of critical minerals over the long term by developing domestic industries supported by mineral recycling.

Acknowledgements

The authors were supported by the Climate Compatible Growth (CCG) programme, which is funded by the Foreign, Commonwealth and Development Office of HM Government. The views expressed in this article do not necessarily reflect the UK Government's official policies. The authors would also like to thank the two reviewers for their thoughtful comments on the policy brief.

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Appendix 1

Table 1 lists the pathways considered in the analysis included in this policy brief and references to more detailed information on the pathways.

ORGANISATION	PATHWAY NAME	YEAR PRODUCED	SOURCE
National Energy System Operator	Electric Engagement	2024	[20]
	Hydrogen Evolution	2024	
	Holistic Transition	2024	
The Climate Change Committee	Balanced Pathway	2020	[21]
	Headwinds	2020	
	Widespread Engagement	2020	
	Widespread Innovation	2020	
	Tailwinds	2020	
Centre for Research into Energy Demand Solutions	Shift	2022	[22]
	Transform	2022	

TABLE 1: LIST OF PATHWAYS INCLUDED IN THE FINAL ANALYSIS.

Appendix 2

Table 2 provides an overview of the cobalt, graphite and lithium use in energy and transport technologies considered in this analysis. Data is drawn from the open-source critical mineral intensity database put together by Cervantes Barron and Cullen [23]

TECHNOLOGY CATEGORY	END USE TECHNOLOGY	POWER SYSTEM	COBALT	GRAPHITE	LITHIUM
Light Duty Vehicle	Small Car	ICE	0	0	0.006
		BEV - NMC	7.98	39.78	5.34
		BEV - LFP	0	51.78	5.34
	Medium car	ICE	0	0	0.006
		BEV - NMC	12.413	61.880	8.307
		BEV - LFP	0	8.547	8.307
	Large car or SUV	ICE	0	0	0.006
		BEV - NMC	17.773	88.4	11.867
		BEV - LFP	0	115.067	11.867
	Van	ICE	0	0	0.006
		BEV - NMC	44	212	28
		BEV - LFP	0	264	24
Mass transit	Bus	ICE	0	0	0
		BEV - NMC	82.5	397.5	52.5
		BEV - LFP	0	495	45
Heavy goods vehicles	Lorry	ICE	0	0	0
		BEV - NMC	88	4242	56
		BEV - LFP	0	528	48
		Fuel cell	0.288	1.328	0.176
Renewable energy generation	Wind power	Onshore wind	0	0	0
		Offshore wind	0	0	0
	Solar PV	Solar	0	0	0
	Hydropower	Hydropower	0	0	0
	Geothermal	Geothermal	0	0	0
	Biomass	Biomass	0.962	0	0
Other	Nuclear Power	Nuclear	0	0	0
Fossil fuel energy generation	Gas fired power plant	Natural gas	0	0	0
	Coal power plant	Coal	200	0	0
Carbon capture and storage	Biomass + CCS	Biomass	8.783	0	0
	Coal + CCS	Coal	274.167	0	0
	Gas + CCS	Natural gas	7.5	0	0
Power storage	Battery storage	NMC	0.15	0.822	0.1
		LFP	0	1.1	0.1
Hydrogen production	Electrolysis	Green hydrogen	0	0	0
	Steam Methane Reforming + CCS	Blue hydrogen	0	0	0

TABLE 2: FULL LIST OF TECHNOLOGIES INCLUDED IN THE ANALYSIS (ICE = INTERNAL COMBUSTION ENGINE, BEV = BATTERY ELECTRIC VEHICLE, NMC = NICKEL MANGANESE COBALT BATTERY, LFP = LITHIUM IRON PHOSPHATE BATTERY). LIGHT DUTY VEHICLES, MASS TRANSIT AND HEAVY GOODS VEHICLE UNITS ARE GIVEN IN KG/VEHICLE. POWER STORAGE UNITS ARE GIVEN IN KG/KWH. ALL OTHERS GIVEN IN KG/MW

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WHO WE ARE

CAMBRIDGE CRITICAL MATERIALS LAB

We believe the energy transition must be equitable and inclusive. That means mineral-rich countries and their communities should benefit fully from their resources. By co-creating information platforms, producing rigorous research, and building tools for better decision-making, we work to strengthen equity in how critical materials are used to ensure no one is left behind.

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HOW WE WORK

We combine independent, interdisciplinary research with close collaboration across the Global South to ensure mineral governance is technically sound, socially just, and climate-compatible. By integrating engineering, policy, and social sciences, we create actionable insights that empower governments and communities to defend their rights, advance their interests, and navigate the complex environmental, social, and economic challenges of the energy transition.

OUR TEAM

Blending engineering, policy, and social sciences, our team finds innovative solutions to complex challenges.