



University
of Exeter



Material Risks

Beyond Batteries and
Traction Motors for the UK
Electric Vehicle Industry

Insight Report for the UK
Advanced Propulsion Centre

Executive Summary

The transition of the UK automotive sector from century-long dominance of the internal combustion engine (ICE) towards electrified vehicles (EVs) and autonomous vehicles (AVs) represents an unprecedented structural disruption. While initial industrial policy and public discourse have focused almost exclusively on the lithium-ion EV battery with its core minerals – lithium, cobalt, nickel – and the rare-earth intensive permanent magnet traction motors (REE-PM motors), the transition towards EV and AV depends on a far broader and more complex spectrum of critical materials embedded within non-battery and REE-PM non-traction motor components.

Subcomponents and systems such as silicon-carbide-based power electronics, advanced sensing equipment for autonomous driving and energy power management, and multi-material, light-weighted chassis structures (often accounting for 40 to 50% of the vehicle mass) contain a wide range of materials. These materials have equal or even greater supply chain risk exposure than those found within EV batteries and REE-PM-based traction motors. As the industry moves towards software-defined vehicles with higher levels of automation, the demand for “computation”, “energy management”, “sensor” materials – including gallium, germanium, yttrium, in addition to various other rare earth elements – is likely to significantly accelerate the conservative assumptions of the materials needs for the scale of EV adoption in the UK and globally for the export markets. This will further intensify and broaden the material risk exposure for the UK EV and wider automotive industry.

As a result of this study – involving thorough desktop-research, interviews with 12 stakeholders across all tiers of the UK EV value chain, and information from 23 additional stakeholders – several key risks emerge:

- **Geopolitical and trade risks:** Concentration of supply in few countries, trade tensions, and export restrictions threaten the availability of critical materials.
 - **Operational and supply chain risks:** Disruptions to logistics chains, equipment downtime, and shortages of critical components can halt production.
 - **Regulatory ESG and decarbonisation pressures:** Increasing regulatory requirements for environmental sustainability, social responsibility, and governance (ESG) pose significant challenges for UK automotive manufacturers.
 - **Financial, pricing, and volatility risks:** Rising demand for critical materials, price fluctuations, and supply chain disruptions can impact profit margins and production.
- In terms of materials, we highlight the following:
- **OEMs know the materials in EVs** because they have access to comprehensive international data, but they know the supply chains less well and it is the Tier X suppliers who were more concerned about supply risks.
 - The number of raw materials now defined as ‘critical’ (important, difficult to substitute but at risk of supply disruption) is high and **many, if not most, of the raw materials in EVs are in the ‘critical’ category both in the UK list and in a global compilation.**
 - Using the GREET and BEV-Sim-models, the BOM categories for a light commercial vehicle, the results show that for **about 70% of the vehicle’s weight and in almost all components, there are materials which will not have been sufficiently studied in academic research and public discourse.**
 - Across components, the **highest emerging material risks** are concentrated in electronics and power systems, high-volume structural materials (e.g. steel and aluminium), and distributed subcomponents where small quantities of critical materials are embedded across multiple systems.
 - For the chassis and body of EVs, key challenges are the decarbonisation and regulatory challenges for steel and **aluminium**, including increasing recycled supplies, including **polymers** (e.g. for bumpers).

Magnesium and alloys with specialist metals like niobium and scandium are an opportunity for lightweighting if secure and price-competitive supplies are available. UK car manufacturers (OEMs) are closely involved in the design and the manufacturing of the car chassis and body.

- There are **rare earth magnets in motors throughout EVs**, in addition to the main traction motors and these have all the same supply concerns as the main traction motors. They are more difficult to recover in recycling.
- Powertrain materials such as **silicon carbides (SiC)** and **gallium nitride (GaN)** are considered critical by UK automotive actors. Copper will see a significant uplift in demand.
- **Electronics** are used throughout EVs and contain multiple critical raw materials, many with few sources of supply. There is little manufacturing in the UK though and so securing these supply chains requires significant international cooperation and domestic capability building.
- **Adhesives and bonding** technologies can also have niche suppliers.

To mitigate these material risks beyond EV-battery and REE-PM-traction motor materials several interventions to boost resilience of the UK-based automotive sector were proposed, including

- **Substitution and material efficiency opportunities:** Research and development of alternative materials, standardisation, and reduction of excess stock.
- **Local sourcing and processing opportunities:** Development of domestic mining projects especially tin, tungsten and copper, midstream processing capabilities, and recycling infrastructure.
- **Data transparency and forward-looking scenario exploration:** Establishment of a national data observatory, pre-competitive data pooling, and scenario planning to improve supply chain visibility and resilience.
- **Supply chain connectivity and demand signalling:** Coordination mechanisms, deep-dive projects, and demand aggregation to improve supply chain coordination and reduce risks.
- **Break-through funding and systemic capability building:** Dedicated funding programs, accelerator initiatives, and capability building to support the adoption of new technologies and processes.

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1 Introduction

The automotive industry is on the cusp of a significant disruption with the advent of EVs and potentially autonomous vehicles, which will dramatically alter the chemistry of various components. As the industry prepares for the massive scaling of these technologies, it is essential to look beyond the commonly discussed materials like batteries and rare earth element (REE) traction motors. According to recent projections, by 2030-2035, most new vehicles placed on the market are expected to have electrical motor components. To address this shift, a research project has been initiated to explore critical materials beyond EV batteries and REE-based traction motors, with the goal of identifying potential risks and mitigation strategies to strengthen the resilience of the UK automotive sector.

1.1 Core research questions

This project involves desktop research, stakeholder interviews and correspondence, and a validation workshop to produce a report addressing three core research questions:

- **RQ 1:** Are there critical materials beyond EV batteries and REE in traction motors?
- **RQ 2:** What are the main risks in the (upstream) value chains for critical materials and components?
- **RQ 3:** What are the major gaps in the mitigation of the identified risks?

In this context, 'material risk' refers to the potential for disruption, constraint, or increased cost in the supply of materials critical to EV production, arising from geopolitical, operational, regulatory, or market-related factors, among others.

1.2 Context and scope

The expectations are that two waves of disruptions will be impacting the UK (and global) automotive industry over the next decade with profound implications on the bill of materials (BOM) and resulting (upstream) value chain risks (see figure 1).

In the first wave of the electrification of propulsion systems, current UK estimates indicate that 80% of vehicles placed on the market will be zero emission by 2030, increasing to 100% by 2035. This shift will directly affect up to 30% to 40% of the BOM by weight, by swapping energy storage from fuel tanks to batteries, and internal combustion engines to electric traction motors. These direct changes beyond the EV battery and the REE-PM traction motors will also affect the rest of the bill of materials as energy and power management systems are required. The body and chassis are also being redesigned, leveraging different and novel material types to lightweight the vehicles to compensate for higher weight of batteries.

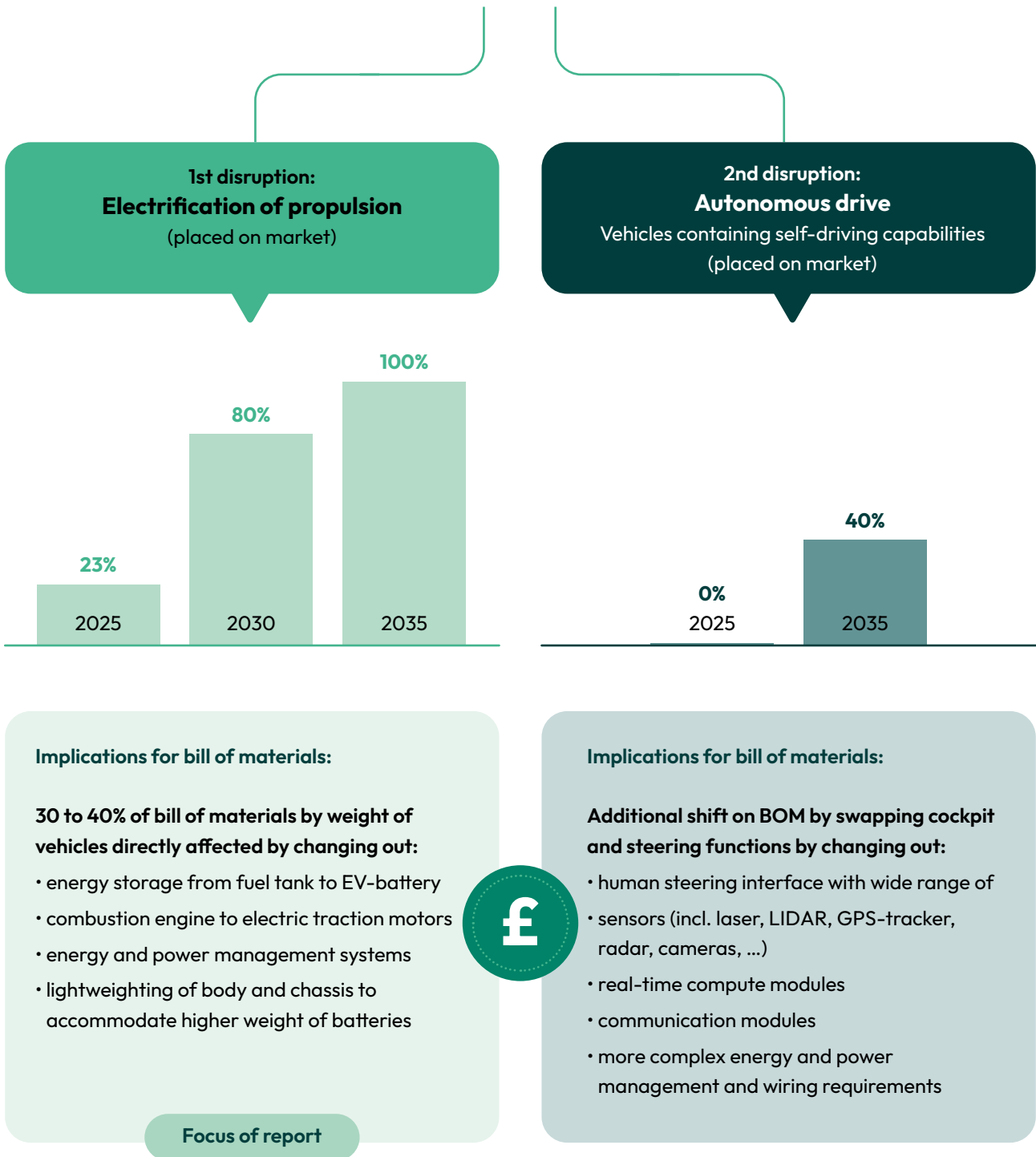
In the second wave towards increasingly autonomous drive vehicles, the need to replace the human in the cockpit will require the introduction of a wide range of sensors including laser, LIDAR, GPS, radar-sensors, optical cameras as well as significantly upgraded compute and communication modules. All these technologies will further alter the BOM to an increasingly larger set of high-performance materials frequently found on criticality lists across different jurisdictions. For the UK the estimate is, that by 2035 up to 40% of vehicles placed on the market will contain self-driving components.

The specific scope of the study is on:

- **Electric vehicles in passenger cars**, excluding electric vehicles for haulage, public transport (e.g. buses) and off-road equipment (e.g. building and farming vehicles).
- **The electrification of propulsion** (first wave) excluding the further disruptions to the BOM that will result from the migration to more autonomous vehicles.

Figure 1: Context of incoming EV and autonomous disruptions for the UK automotive industry

UK automotive industry facing two major disruptions with significant impact on material composition and upstream value chain risk exposures

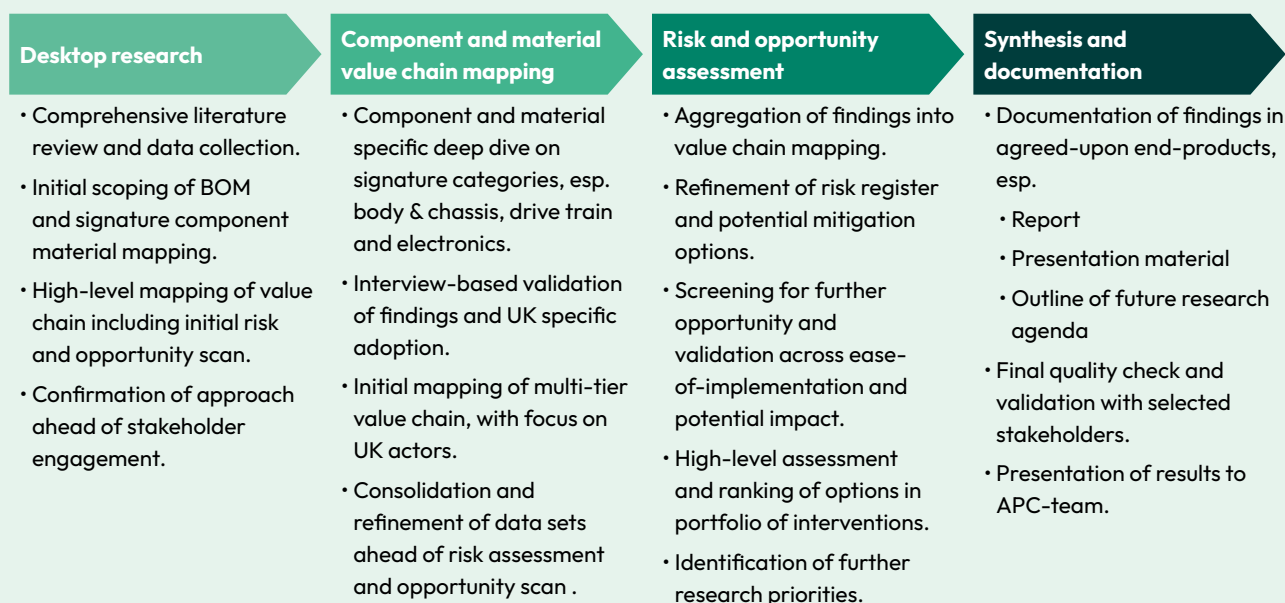


Source: CMIC, SMMT, literature research, National Grid Energy transition, Centre for Connected and Autonomous Vehicles (CCAV)

2 Methodology

Figure 2: Methods and approach

To engage stakeholders effectively and to reach sufficient depth, we took a proven four step research approach



Engagement of stakeholders via interviews, presentation of (intermediate) results and workshop

The project employed a multi-faceted approach (see figure 2) to investigate critical materials beyond EV batteries and REE-based traction motors. The methods used were designed to gather comprehensive insights from various stakeholders, experts, and existing literature.

Desktop and literature research

Desktop research was conducted to identify and review existing studies, reports, and data related to the topic. This involved analysing industry trends, market forecasts, and technical publications to gain a deeper understanding of the automotive sector's transition to EVs. The desktop research provided a foundation for the project, allowing the team to develop a comprehensive knowledge base and identify key areas for further investigation. The literature research

confirmed that most of the attention had gone so far to EV batteries and REE-PM traction motors. Of the 765 articles identified in Scopus on EV, material flow and life cycle management and resource risks and mitigation strategies, more than 85% focused on the EV battery and/or the traction motors.

Expert and industry interviews

To gather more in-depth insights and expertise, 12 semi-structured stakeholder interviews were conducted with industry professionals, academics, and experts in the field. These interviews were conducted in-person or online and aimed to capture the perspectives and experiences of individuals closely involved in the automotive sector's transition to EVs across the UK-specific automotive value chain including OEMs, Tier-X and material suppliers, academia and industry experts

focused on LCA and critical material assessment in the UK automotive sector and trade associations. The interviews were designed to identify potential risks, challenges, and opportunities associated with the adoption of new materials and technologies and to embed this into the UK automotive industry. Interview partners were identified by the research team, complemented by APC-assessment, to ensure full coverage of the UK value chain (see Appendix).

Validation workshop

The project team hosted one validation workshop, where stakeholders and experts gathered to discuss and validate the findings from the desktop research and stakeholder interviews. This workshop provided a platform for open discussion, debate, and feedback, ensuring that the project's outcomes were grounded in reality and reflected the concerns and priorities of the industry.

APC-round-table

As part of the “Future-Proofing UK automotive Manufacturing: Strategies for Competitiveness and Growth” in person workshop on the 19th of March in London, a break-out session on “Resilience” was moderated by APC looking at a) upstream automotive supply chain exposure over the last 5 years, b) potential future bottlenecks for materials and components for UK production, c) potential most effective source of resilience for UK-based actors and d) potential actions for APC to meaningfully strengthen the UK supply-chain resilience. The results of this round-table exercise were recorded and synthesised by the research team to include in this report.

The application of this mixed-method approach via the combination of desktop research, stakeholder interviews, and two validation events facilitated a comprehensive understanding of the research topic, triangulating data from multiple sources to increase the validity and reliability of the findings. While this report contains the input of the parties involved (see list of participating entities in the Appendix, total of 65 entities), the result is solely based on the final, independent appraisal and collation by the research team.



3 Key insights against research questions

The results of the report are presented in the following section following the structure of the three research questions. The scope of EV component and material value chains is vast, so the insights are presented in an abridged and selected fashion to illustrate observations and examples. The insights will be applicable to other component and material combinations.

3.1 RQ1: Materials beyond EV batteries and REE-PM traction motors

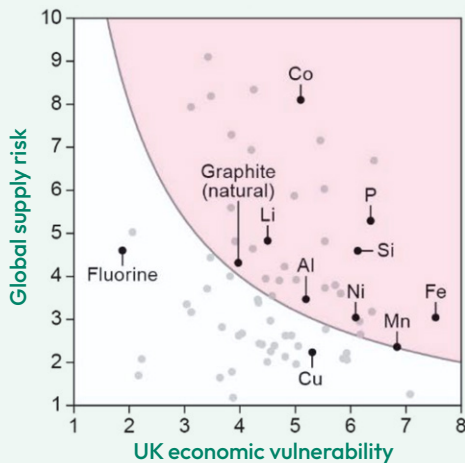
Across components, the highest emerging material risks are concentrated in electronics and power systems, high-volume structural materials (e.g. steel and aluminium), and distributed subcomponents where small quantities of critical materials are embedded across multiple systems. The following subsections illustrate these patterns across major EV component groups.

EV battery materials (especially lithium, cobalt, graphite) and REE-PM traction motor materials (especially dysprosium, neodymium) have attracted

a significant amount of research and consideration. For the UK the latest compilation by the UK Critical Minerals Intelligence Centre in 2024¹ identified 11 materials alone for the lithium-based technologies and 5 further materials as critical for other battery technologies (see figure 3).

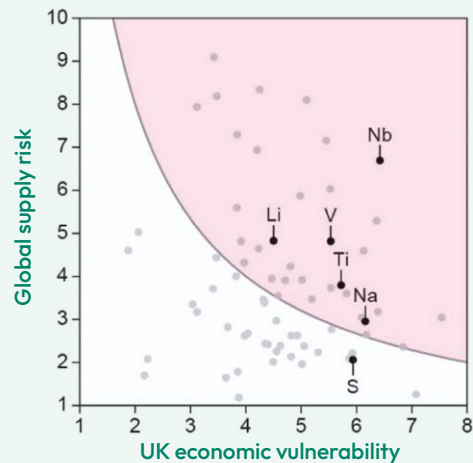
To identify the materials ‘beyond EV batteries and REE-PM traction motor materials’, the analysis here comprised identification of a detailed EV bill of materials (BOM) leveraging the GREET² and BEV-Sim-model to obtain a split of the EV into major components and embedded materials. In these models trace elements (specific REE or materials with very low quantities, e.g. gold, silver, palladium) are frequently not quantified in detail and so dedicated LCA literature was used to obtain more information on selected components, especially powertrain subsystems and electronic controls known to contain these materials. The wide range of product and material specifications that use a number of additives in varying

Figure 3: Materials identified as critical by CMIC in 2024 for different EV battery technologies



EV-Battery materials (lithium based)

- Cobalt
- Lithium
- Aluminium
- Nickel
- Manganese
- Iron
- Graphite
- Phosphorus
- Silicon
- Fluorine
- Copper



EV-Battery materials (other technologies)

- Sodium
- Vanadium
- Niobium
- Sulphur
- Titanium

1. Mudd et al., UK 2024 Criticality Assessment. British Geological Survey Open Report, OR/24/04
 2. U.S. Department of Energy - GREET model. Available at: <https://www.energy.gov/cmei/greet>

concentrations, such as polymers, complex alloys and increasingly composite materials, were maintained at an aggregated level, and represented as material types, such as ‘plastics’ in our representation.

The results are presented in figure 4 by leveraging the GREET-taxonomy for EV-components and mapping the embedded materials into 3 groups. The first group comprises materials predominantly embedded only in EV batteries and REE-PM traction motors (marked green). The second group comprises materials embedded in EV batteries and REE-PM traction motors (marked in yellow) as well as in other components of the vehicle. REE did not appear in this group in the GREET model but were clearly indicated as being important in the many motors throughout an EV during the interviews. The third group (marked in red) comprises those materials, which predominantly are not found in EV batteries and REE-PM traction motors.

Using the BOM categories for a light commercial vehicle³, the results show that for about 70% of the vehicle’s weight (see figure 4) and in almost all components, there are materials which will not have been sufficiently studied in academic research and public discourse. But these materials are pivotal to deliver the performance needs of EVs across component types.

3.1.1 Body

The body comprises the body-in-white, body interior, body exterior and vehicle glass. The drive for efficiency in EVs has reinvigorated interest in lightweighting, as reducing vehicle mass directly reduces the required battery capacity – the most expensive part of the vehicle. This shift is moving the industry away from traditional mild steel towards advanced high-strength steels (AHSS) (some including niobium), aluminium alloys (some including REE like scandium), magnesium, and carbon fibre composites. Adjustable components like seats and mirrors are complex sub-components containing electronic equipment and actuators (e.g. also REE-PM magnet motors). The finishing of the interior consists frequently of complex polymers with a large set of additives and pigments to adhere to a wide range of aesthetic and functional performance criteria. Given that the body largely defines the brand appearance and user experience of the vehicles, UK car manufacturers (OEMs) are closely involved in the design and the manufacturing of this component. Manufacturing of the major body parts is therefore also performed primarily within the UK. For a light EV, the weight of these components amounts to around 30% of the total weight (GREET Model, figure 4).

Figure 4: Selected materials identified in EV components (split by weight for light EV in percent) using the GREET model.

EV-breakdown by weight (in percent)	Battery / traction materials	Beyond EV battery materials
EV-batteries 24	Mainly EV-battery & traction motors: Graphite, Lithium, Cobalt, Glycol	
Traction Motors 5	Silicone, Nylon	
Battery & motor 29	Also present in batteries & traction motors:	Mostly beyond battery & traction motors:
Body 30	Steel, Cast aluminium, Copper, REE	Carbon fibre, Plastics, Aluminium (sheet & extrusion), Glass, Rubber, Magnesium, Zinc
Chassis 22	Steel, Cast aluminium, Copper/brass, REE	Cast iron, Aluminium (extrusion), Magnesium
Electronic controller 5	Copper, Nickel, Epoxy, Copper, Cast aluminium, Rare earth elements, REE	Plastics, Gold, Silver, Palladium, Tantalum, Niobium, Antimony, Tin, Germanium, Silicon
Powertrain subsystem 5	Copper/brass	Plastics, Aluminium, Rubber, Gallium Nitride, Silicon carbide
Transmission / gearbox 5	Steel, Aluminium, Copper	
Tyres 2		Rubber
Fluids 2		Water, oil, synthetic fluids, refrigerants
29%	71%	

3. Hopkinson, P. et al. (2025) Circular Economy Data Observatory light passenger vehicles final report: Material flow analysis (MFA) focusing on light passenger vehicles in the UK (RDE807). Circular Economy Data Observatory (CE-DO) project, University of Exeter, on behalf of Defra Circular Economy Science: Strategic Evidence and Analysis.

In addition to metals, a wide range of polymers in quantities of up to 200 kg are required (e.g. for bumpers, dashboards, internal panels, noise and electric insulation) within the body. Adhesives and bonding technologies are required to fix structures in the vehicles.

3.1.2 Chassis

The chassis is the main structural frame of the vehicle, which houses steering and braking systems, suspension and axles for the wheels. The chassis is made from structural steel, aluminium, cast iron and advanced high-strength alloys. To protect the chassis against corrosion, zinc is frequently used to encapsulate components with a galvanised protective layer. For a light EV the weight of these components amounts to 22% of the total weight (GREET model, see figure 4). As with the body, the chassis is typically manufactured and assembled in the UK.

3.1.3 Electronic controller

The electronic controller refers to the systems responsible for managing power distribution, control functions and signal processing across the vehicle. The subcomponents of the electronic controller consist of a wide range of technologically advanced parts with multi-tier and often global value chains such as power controllers, phase inverters, passive cooling systems and other associated hardware, which are distributed throughout the vehicle. The electronic components on the printed circuit boards consist of a large set of high-value materials such as gold, silver, palladium, germanium and other trace materials. The wiring frequently requires copper, nickel and tin which are insulated using polymer resins and epoxy bonds to fix the components in the vehicles.

3.1.4 Powertrain subsystems

The powertrain subsystem primarily consists of the electric traction motor and associated hardware. For this study, we have extracted the traction motor from the list and considered it separately. The remaining components contain the onboard charging inverter. Materials such as silicon carbides (SiC) and gallium nitride (GaN) are considered critical by UK automotive actors. Copper will see a significant uplift in demand as an EV contains up to 4 times more copper than an ICE vehicle (20kg in ICE vs. 80+ kg BEV), especially in the wiring⁴ and components of EV-specific technologies, such as the powertrain subsystems⁵.

3.1.5 Transmission and gearboxes

Transmission and gearboxes are the link between the traction motor and the power transmission to the wheels. These components require strong and robust components frequently made of steel with advanced finished surfaces to reduce wear and tear. While technologically simpler in design (single speed reduction gearboxes) and with fewer parts compared with ICE gearboxes, EV gearboxes need to be able to deliver maximum torque efficiently across a wide operating range of speeds up to 20,000 RPM. They must also be designed to withstand thermal stress generated during rapid acceleration and regenerative braking, as well as maintain proper electrical insulation to protect adjacent high-voltage components from stray currents.

3.1.6 Other EV components

Tyres are made from rubber with a wide range of additives and reinforcement by different materials. Fluids are used in various applications ranging from braking systems, refrigerants for air conditioning, (battery) cooling systems and windscreen cleaning and comprise very different materials from water, oil and synthetic fluids. There are many materials in small quantities spread throughout all components of the vehicles, ranging from high performance materials (like REE) to adhesives and bonding materials, which are essential to deliver the required performance not only in EV batteries and REE-PM traction motors, but also in almost all other component types.

3.1.7 Autonomous drive components

While out of scope for this study, the advent of a wide range of sensors (30+) will increase the demand for technology metals even further and elevate the complexity of the upstream multi-tier value chain. These components will drive further up the demand for a wide range of critical minerals required in the necessary sensor and compute units, such as gallium, germanium, indium, palladium, tantalum. The optical devices (e.g. LIDAR scanners) will require microelectromechanical systems such as mirrors fabricated from single-crystal silicon and thin silicon dioxide layers; materials currently not present at scale within EVs. To manage the additional heat of the higher performing printed circuit boards (PCBs), there will probably be increased demand for copper.

4. Colin Bennett, The International Copper Association (2022): <https://internationalcopper.org/resource/copper-the-material-of-choice-for-vehicle-manufacturers/>

5. Rietveld, E et al., (2022), Strengthening the security of supply of products containing Critical Raw Materials for the green transition and decarbonisation, Publication for the committee on Industry, Research and Energy (ITRE), Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg.

3.2 RQ2: major material (upstream) value chain risks

The UK Critical Minerals Intelligence Centre has compiled a comprehensive list of critical materials for all major industries operating in the UK⁶. Minerals or raw materials deemed critical are economically important but vulnerable to supply disruption. This list contains 34 critical materials and many of these are highly relevant to the automotive industry (see figure 5). Moreover, most appear on the critical lists globally, not just in the UK, as shown by comparing with the critical mineral lists for Australia, EU, Canada and USA in figure 5. Given that the automotive industry is global, an experimental deeper dive into global

supply chain vulnerability for automotive elements was performed using criticality assessment factors and these results are given in the Appendix.

Across the identified categories, risks associated with geopolitical concentration of supply, increasing ESG and regulatory requirements, and limited visibility across multi-tier supply chains appear particularly significant. These risks are often most pronounced in electronics and distributed component systems, where small quantities of critical materials are embedded across complex value chains.

Figure 5: Many of the elements identified in the UK 2024 criticality assessment as relevant to the automotive industry were classified as critical and are on most other countries' critical lists.

Material	UK CMIC Automotive Relevance	UK critical	Australia, EU, USA, Canada critical
Aluminium	High	✓	✓
Boron	Medium		
Chromium	Medium		
Cobalt	Medium (battery)	✓	✓
Copper	High		
Fluorspar	Medium		
Gallium	Medium	✓	✓
Germanium	Medium	✓	✓
Graphite (Natural)	High (battery)	✓	✓
Indium	Medium	✓	
Iron	High	✓	
Lithium	High (battery)	✓	✓
Magnesium	High	✓	✓
Manganese	High (battery)	✓	✓
Molybdenum	Medium		
Nickel	High (battery)	✓	✓
Niobium	Medium	✓	✓
Phosphorus	Medium (battery)	✓	
Platinum Group Metals	High (petrol/fuel cell)	✓	✓
Rare Earth Elements (group)	High	✓	✓
Scandium	Medium	✓	✓
Silicon (metal)	High	✓	✓
Silver	Medium		
Tantalum	Medium	✓	✓
Tellurium	Medium	✓	✓
Tin	High	✓	
Titanium	High	✓	✓
Tungsten	High	✓	✓
Vanadium	High	✓	✓
Zinc	Medium	✓	
Zirconium	Medium		

6. Mudd et al., (2024) UK 2024 Criticality Assessment. British Geological Survey Open Report, OR/24/04

3.2.1 Geopolitical and trade induced risks

The geopolitical and trade induced risks address the question “how to get and secure access at all?” to critical materials. The most significant risk is the extreme concentration of the supply and processing of critical minerals. For materials like REE (magnets), gallium (power electronics), and germanium (sensors), the UK is nearly 100% dependent on imports, often from single-source nations. China’s dominance in both the extraction and refining of these materials means that any trade tension or export restriction can immediately halt production for UK Tier 1 suppliers. The UK’s target of limiting single-source imports to no more than 60% by 2035 is an ambitious goal that will require significant international cooperation and domestic capability building. Automotive supply chains are famously lean, and a single supply disruption among Tier 3 raw material suppliers can halt an OEM’s assembly line within 72 hours.

3.2.2 Operational and supply chain risks

The operational and supply chain risks impact the ability to get access to material and components and to manufacture reliably without any shortage of supply. In addition to the geopolitical and trade induced risks, where materials might not become available at the right quantity, operational and supply chain issues entail risks related to disruptions of physical logistics chain, downtime of critical equipment in the logistics and manufacturing tool chain. Examples like Covid-19, Suez Canal blockage, Ukraine war (wiring harnesses) have disrupted logistics chains profoundly, emphasising the need and benefits for thinking about improving resilience of supply chains in the future even further, also for materials beyond EV batteries and REE-PM traction motors. Additionally, the upstream value chains for semiconductors and high-tech chips remain largely opaque, where shortages have already created critical bottlenecks for electronic components.

3.2.3 Regulatory ESG and decarbonisation towards net-zero pressures

The UK automotive manufacturing sector is facing increasing regulatory and ESG pressure, driven by a range of incoming regulations across the EU, UK, and other major jurisdictions. For example, the Corporate Sustainability Reporting Directive (CSRD) requires

companies to disclose detailed information on their environmental and social impacts, while the Corporate Sustainability Due Diligence Directive (CSDDD) mandates companies to identify, prevent, and mitigate adverse human rights and environmental impacts throughout their supply chains. Additionally, regulations such as the Deforestation Regulation (EUDR) and the Carbon Border Adjustment Mechanism (CBAM) impose strict requirements on companies to ensure that their supply chains are free from deforestation and carbon-intensive practices. These regulations pose significant challenges for UK automotive manufacturers, including the need to track and report Scope 3 emissions, conduct deep-tier due diligence, and implement data infrastructures to trace and share material composition and carbon footprints digitally. For instance, under the CSRD, OEMs must track and publicly report Scope 3 emissions across their entire upstream supply chain, while Tier-X and local materials suppliers will face intense data requests from OEMs regarding their carbon, energy, and labour footprints. Similarly, the CBAM will impose a carbon price on imports of highly carbon-intensive goods, such as steel and aluminium, which will increase costs for UK automotive manufacturers that rely on these materials (see also a list of regulations in the Appendix). In addition to these regulatory requirements, customers are asking UK-based upstream component and material providers for detailed compliance with internal reporting standards ahead of regulation, in response to strong pull from OEMs and final customer markets.

3.2.4 Financial, pricing and volatility risks

The massive increase in demand for new materials driven by the transition to EVs and autonomous vehicles poses significant financial, pricing, and volatility risks. As demand exceeds current levels of output, prices for critical materials are likely to rise, leading to increased costs for manufacturers and potentially impacting profit margins. Furthermore, the volatility of these markets could lead to price fluctuations, making it challenging for companies to predict and manage their costs. The risk of supply chain disruptions and bottlenecks is also increasing, which could result in delays or shortages of critical components, ultimately affecting the overall production and delivery of EVs and autonomous vehicles.

3.2.5 Material quality and consistency risks

The introduction of reverse value chains to revalorise previously used materials in the automotive industry poses potential material quality and consistency risks. As recycled or reused materials are reintroduced into the supply chain, there is a risk of variability in their quality, composition, and performance. This can lead to inconsistencies in the final product, potentially affecting its safety, reliability, and overall quality. Additionally, the use of recycled materials may introduce contaminants or impurities that can impact the material's properties and behaviour. Ensuring the quality and consistency of these materials will require robust testing, inspection, and certification protocols, as well as effective sorting and processing techniques to minimise the risk of contamination. Moreover, the variability in feedstock quality and the potential for mixing of different material streams can make it challenging to guarantee the consistency of the recycled materials, highlighting the need for advanced characterisation and monitoring technologies to mitigate these risks. For instance, a higher proportion of copper or manganese in the harvested feedstocks can reduce

the efficiency of steel recycling, while mixed polymer streams and additives can limit the recyclability and performance of plastics. This can often result in downcycling rather than closed-loop reuse.

3.2.6 Overview and heat-map of risk exposure by major component types

When overlaying these broad risk categories with the different non-EV battery and REE-PM traction motors a more nuanced picture evolves on the potential exposure. Figure 6 summarises this differentiated picture.

The geopolitical and trade risks as well as the resulting financial, pricing and volatility risks, have been widely studied for EV batteries and REE-PM traction motors, however, the introduction of new regulations (specifically in the EU) increases the risk from regulatory ESG and decarbonisation pressures, as the required mandate for the reporting, recycled content, etc. is not easy to address given current knowledge. These same ESG-risks are prevalent for almost all other EV components. For large volume materials consisting of steel, aluminium, other metals

Figure 6: Indicative scoring of risk types versus EV-components



Figure 7: Risk profiles for signature EV materials (excluding batteries and the main REE traction motor) grouped into four types

Groups	Signature materials	Typical applications	Major risks (selection)
Large volume structural and mechanical materials	<ul style="list-style-type: none"> • Steel • Aluminium • Composites 	<ul style="list-style-type: none"> • Body • Chassis • Transmission, gearbox 	<ul style="list-style-type: none"> • ESG & regulatory risks (decarbonisation of process, green materials) • Price volatility risks • Major driver of Carbon Emissions
Mid volume, materials	<ul style="list-style-type: none"> • Glass • Plastics • Rubber 	<ul style="list-style-type: none"> • Body • Encasings • Tyres 	<ul style="list-style-type: none"> • ESG & regulatory risks (decarbonisation of process, green materials) • Price volatility risks
Technology materials	<ul style="list-style-type: none"> • Copper / brass • Iron 	<ul style="list-style-type: none"> • Power train • Mechanical parts 	<ul style="list-style-type: none"> • Price volatility risks • Supply disruption risks • Opaque value chains largely outside the UK
High performance trace materials	<ul style="list-style-type: none"> • Trace elements (CMIC elements) • REE • Magnesium (for lightweighting) • Germanium • Gallium 	<ul style="list-style-type: none"> • Electronic controller • Embedded in almost all other components to achieve high-performance as trace elements /additives 	<ul style="list-style-type: none"> • Price risks • Concentration risks • Supply disruption risks • Hidden risks on upstream visibility (multi-tier layer)

and various plastics strands, which in theory all have a high (local) recycling potential, the diversification of compounds and additives in the alloys and special purpose plastics add to the challenge for recycling back to the same quality consistently over time, given the variation in the harvested post-use feedstocks. As soon as electronic components, power-systems, actuators and smaller motors are part of the component, the concerns about geopolitical and trade risks are of equal importance to those already investigated for EV batteries and REE permanent magnet motors. Given the large variance in sub-components and modules, the opaqueness of the value chain is deemed even higher.

For summarising risk profiles, we suggest grouping the different material types into four distinct groups (see figure 7).

3.3 RQ3: major gaps in the mitigation of risks

Despite ongoing mitigation efforts across the UK automotive sector, several critical gaps remain.

These include:

- i) limited visibility across Tier 2–3 supply chains, particularly for electronics and critical materials;
- ii) insufficient UK midstream processing and recycling capacity to support secure and circular material flows; and
- iii) fragmented data, coordination and collaboration across stakeholders, limiting the ability to respond effectively to emerging risks.

The mitigation of the risks identified in this study can be categorised into four different strategic activities, as described below and summarised in figure 8:

1. Demand side mitigation: By reducing the demand for the risk-exposed materials (e.g. using lower concentrations of the respective material chemistries), developing and changing to suitable substitutes (e.g. composites instead of lightweighted aluminium alloys) and potentially standardisation to reduce excess stock and to improve the intensification of use of the incoming stock the demand can be reduced to improve security of supply and easing pressure on price spikes.

2. Supply side mitigation; The dependence on a few highly concentrated suppliers can be reduced via development of additional or alternative diversified suppliers. By near- or friendshoring, geopolitical and trade risks as well as potential disruptions to the logistics chain can be mitigated (sometimes at a higher cost). Alternative sources of supply can also be developed by improving revalorisation of existing stock post-use via circular economy interventions such as component reuse, remanufacturing and recycling. However this is, in times of technology transformation, a lever that can only come into play once there is an initial cohort of deployed assets that can be revalorised. In the case of EVs this could be over half a decade away at significant scale.

3. Inventory and buffer levers: Against short-term, temporal disruptions in supply as well as to mitigate price peaks in times of prolonged demand-supply imbalance, leveraging stockpiled materials, strategic reserves and safety stocks can be effective tools. However, this instrument is frequently costly as it requires upfront finance for to buy the stocks and to provide sufficient storage capacity.

4. Planning: Predictive forecasting, deep-tier visibility and the required data-pooling and scenario modelling can be tools to screen today's still very opaque value chains for liabilities and future risks. The intelligence gained can be deployed towards early responses within the available lead times and to launch countermeasures (e.g. via financial instruments) to de-risk potential future issues. These planning-side mitigation options benefit from pre-competitive data-pooling and scenario modelling.

Figure 8: Indicative effectiveness of aggregated levers versus identified risk categories

Risk types:	Demand side mitigation options			Inventory & buffer levers			Supply side mitigation options				Planning		
	Demand reduction	Substitution	Product standardisation	Stockpiling	Strategic reserves	Safety stock	Supplier diversification	Supplier development	Near / friendshoring	Revalorisation	Predictive forecasting	Deep-tier visibility	Data pooling
Geopolitical, trade risks	Effective	Effective	Effective	Potentially effective	Potentially effective	Potentially effective	Effective	Effective	Effective	Effective	Potentially effective	Potentially effective	Effective
Operational and supply chain risks	Effective	Effective	Effective	Potentially effective	Potentially effective	Effective	Effective	Potentially effective	Effective	Effective	Effective	Effective	Effective
Regulatory ESG & decarbonisation pressures	Potentially effective	Effective	Potentially effective	Not effective	Not effective	Not effective	Effective	Effective	Effective	Effective	Effective	Effective	Effective
Financial, pricing and volatility risks	Effective	Effective	Effective	Effective	Potentially effective	Potentially effective	Effective	Effective	Effective	Effective	Effective	Effective	Potentially effective
Material quality and consistency risks	Potentially effective	Effective	Effective	Potentially effective	Potentially effective	Effective	Potentially effective	Effective	Potentially effective	Effective	Potentially effective	Effective	Effective

■ Effective
 ■ Potentially effective
 ■ Not effective

Figure 9: Levers available to the UK automotive actors to overcome materials supply risks

Actor:	Demand side mitigation options			Inventory & buffer levers			Supply side mitigation options				Planning		
	Demand reduction	Substitution	Product standardisation	Stockpiling	Strategic reserves	Safety stock	Supplier diversification	Supplier development	Near / friendshoring	Revalorisation	Predictive forecasting	Deep-tier visibility	Data pooling
OEM	Design efficiency	R&D for alternatives	Inter / intra-company			Active SCM	SCM	SCM	SCM	Closed-loop options	SCM	SCM	
Upstream Tier component and material providers	Design efficiency	R&D for alternatives	Inter / intra-company			Active SCM	SCM	SCM	SCM	Closed-loop options	SCM	SCM	
Associations			Standardisation	Informing	Informing				Scouting	Open-loop solutions			Active MFA & risk tracking
Government institutions			Facilitation		Facilitation				Facilitation, enablement				Facilitation, enablement
Academia & research	Design efficiency	R&D for alternatives						Training, R&D	Project assessment		Method development	Method development	Providing backbone

Observation:

- Most levers already addressed by dedicated functions within OEM and Tier-x-players
- Cross-company effort potentially best supported by associations, government bodies and academia

Figure 9 gives a preliminary indication of which type of actor in the UK automotive value chain is likely to pursue each of the four levers, immediately or in the longer term.

Given the immediate relevance for private sector business performance, and the government’s interest in nurturing local industries that provide jobs and competitive offerings, many of these levers are already being actively pursued. Within the UK automotive sector, OEMs and suppliers frequently have dedicated functions focused on specific types of risks, such as procurement and supply chain management for supply-side risks, compliance and business development functions for ESG-related risks, and R&D and engineering for identifying substitutes and reducing reliance on critical materials.

However, the interviews and workshops have highlighted several areas where these mitigation efforts could be further strengthened, including:

- **ability to extend the scope of investigated material-component-combinations** to specific categories beyond those, which have received already a lot of attention (e.g. higher transparency for opaque value chains of semiconductor and electronics components)
- **pre-competitive collaboration on material high volume material streams** and potentially fewer capability gaps in the UK automotive sector (e.g. options to close the loop on plastics and metal recycling locally) or to promote leveraging of local sourcing alternatives (e.g. local mining projects, research on substitutes)
- **data pooling and bundling efforts across the sector**, e.g. by supporting legislator in defining sensible targets and encouraging models of mutual interest to UK-based stakeholders.

4 Recommendations

Reflecting on the identified risk and potential gaps in the mitigation strategies present in the UK automotive sector, a set of recommendations have been formulated with three major framings in mind.

- Would those initiatives be suitable for APC?
- Would these initiatives allow pre-competitive collaboration within the UK automotive industry?
- Would these initiatives focus on UK-specific opportunities?

4.1 The substitution and material efficiency opportunity

The systematic search for substitution and alternative sources involves sponsoring dedicated research and development projects for alternative critical feedstocks, systematically reviewing local mining and processing alternatives, and mandating the build-up of a national material-focused data observatory. The 'what' in this opportunity is searching for substitution and alternative sources, the 'why' is to reduce supply chain risks and improve resilience, and the 'how' is through sponsoring research and development projects and building up a national inventory of available technologies for introducing material alternatives. APC could play an active role in identifying pre-competitive research programs across different levels of technological readiness levels (TLR) to improve resilience. This could be complemented with collaboration agreements with the UK Manufacturing Technology Centre (MTC) to develop manufacturing processes, innovation and implementation tools for scaling identified alternatives and substitutes (potentially from secondary UK-harvested sources).

4.2 The local sourcing and processing opportunity

Although the UK imports most of its raw materials, including those already combined in materials, components and products, it does have world-class ore deposits and other subsidiary deposits that could supply raw materials to the UK EV industry. Domestic projects are progressing and some may be in production by 2027. South Crofty mine in Cornwall

is re-opening and has high grade cassiterite (tin ore), likewise Hemerdon in Devon is one of the World's largest wolframite reserves (tungsten ore). There are also other tungsten and tin projects under exploration, as well as active projects for nickel, lithium, copper and potential for other elements such as antimony, bismuth, cobalt and arsenic. Thus, there may be some opportunity for a direct UK supply chain, but this will require midstream processing of the ore to produce the refined products that manufacturers need. As things stand now, tin, tungsten and most ores - apart from lithium, potentially - would need to be shipped overseas for onwards processing. More detailed study of the prospective value chains is needed, and could be supported by APC, to establish the best opportunities. For example, even when Tier Xs are based in the UK, they may still be manufacturing their own products overseas. Thus, they might benefit from research on supplies local to them, as well as, or instead of, UK-produced materials.

Tin is used throughout EVs, as solder in all the electronics and various other applications but does not have a major 'signature' application (unlike Li in batteries for example). Key uses of tin in UK EV-related manufacturing include solder and solder-bearing assemblies used by module suppliers for automotive electronic control units and electronics; tin-plating and zinc-tin plating solutions used by UK metal-finishing firms to treat copper wiring, connectors, fasteners and brake components; and tin-based catalysts and tin chemicals used in polyurethane foams and adhesives for automotive interiors and structures, as well as in friction materials, tyres, glass and glass coatings, relay contacts, and bronze, babbitt and aluminium-tin bearings and bushings. Next steps would be to test if there might be direct routes from refined tin to the auto industry.

Tungsten ore (ferberite/wolframite) is also likely to be produced in the UK within a couple of years. Like tin, there is no onward processing of the ore being set up in the UK yet. We heard less about the use of tungsten in EVs although it has applications in brakes and semiconductor wiring and is listed as relevant

to automotive in the UK criticality assessment. An important use is in the hard metals used in manufacturing tools used to make EVs, which is outside of the scope of this study.

Copper minerals occur in projects still at exploration stage (e.g. Cornwall and Aberdeenshire). Production may also be possible from mine waters and waste. Copper was cited as key to many components in EVs⁷ and there may well be an opportunity for a UK-based secure and high-ESG credential copper supply for some EV components. Further research is required to consider the detail of the value chain, and possibilities to link together secondary and primary sources.

Other elements like nickel are under active exploration and antimony, bismuth, arsenic, zinc might also be produced in the UK. More research is needed to see if there are any pathways from raw materials to the EV industry for these elements.

4.3 The UK-based recycling revalorisation opportunity

This initiative involves the exploration of reverse revalorisation options, which enable the recovery and reuse of materials from end-of-life vehicles. By including these options across different levels of tiers, the industry can maximise the value of its materials, reduce waste, minimise its environmental impact, and improve security of supply by retaining and reusing critical minerals in the UK. At present, although the UK generates scrap metals/materials, almost all goes overseas for processing. Some recycled material is already used by EV Tier 3 and 4 suppliers, including those provided by UK recyclers to UK companies, but this may not be known by the OEMs. Supply chains for recycled materials need as much care and attention as primary raw materials, and in future may even be dominated by materials of Chinese origin if there are insufficient local sources to meet regulatory requirements for recycled content. Recyclability of components and materials was a concern of Tier 1s, OEMs and Recyclers. Especially for aluminium, copper, magnets, polymers, interviewed parties suggested, that UK-based collection and reprocessing rates could be further improved by designing for disassembly and

identifying recycling opportunities at national level, rather than at firm-by-firm approaches. Regarding the recycling process the choice of approach could be further improved as the increasing complexity of harvested post-use feedstock increases the challenges to extract the embedded technology metals (e.g. copper, manganese) instead of having those dilute the quality of the steel or the efficiency of the recycling process (e.g. as is already a challenge in today's automotive post-use recycling).

4.4 The UK-based re-use, remanufacturing revalorisation opportunity

Remanufacturing keeps the materials at a higher value rather than going back to individual raw materials. The Toyota Circular Factory at Burnaston⁸, opened in 2025, is an example of development of this kind of good practice, where disassembly of end-of-life vehicles, re-use, repurposing and recycling are combined. Jaguar Land Rover equally has been systematically looking at options to improve component and material recovery⁹, leveraging its Circularity Lab in Gaydon also for non-obvious components as car seats. The automotive post-use revalorisation industry in the UK is also well positioned to channel materials back into productive use for the automotive industry. However, OEM and Tier 1 automotive dismantling and recycling firms find small, complex components, distributed throughout the vehicles and materials challenging to recover and either re-use or recycle economically (e.g. small REE magnet motors) so this is an area that could be improved. Other OEMs may be interested in similar circular initiatives in collaboration with each other, or other companies. From an APC point of view, the creation of a UK-wide company and capabilities map for critical materials and technologies could provide more evidence on UK-based capabilities, identifying further gaps and opportunities to stimulate and propose targeted collaborations between members of the UK automotive sector. Extending the scope of this map towards adjacent industries (e.g. aerospace, defence and energy) with similar technological requirements and challenges could further increase the understanding of the potential solution space.

7. IDTechEx (2017) The Electric Vehicle Market and Copper Demand - <https://internationalcopper.org/wp-content/uploads/2017/06/2017.06-E-Mobility-Factsheet-1.pdf>
8. Toyota (2026) The Toyota Circular Factory: where the end of vehicle life is the beginning of new opportunities - <https://media.toyota.co.uk/the-toyota-circular-factory-where-the-end-of-vehicle-life-is-the-beginning-of-new-opportunities/>
9. Colin Windell for Colin-on-Cars (2024) - <https://www.changecars.co.za/motoring-news/jaguar-uses-new-tech-to-recycle-car-seats>

4.5 Midstream processing and material circularity opportunity

The opportunity of midstream processing and material circularity involves building up local midstream capabilities, such as scrap processing to high-quality aluminium and steel. This is necessary because the UK automotive industry is focused on engineering and assembly, but critical capabilities to de-risk supply chains are not present at scale. To achieve this, demand aggregation can be used to improve the bankability of projects across adjacent industries, and coordination with governmental industrial politics can facilitate the build-up of local midstream capabilities. The what in this opportunity is building up local midstream processing capabilities, the why is to reduce supply chain risks, and the how is through demand aggregation and coordination with government. This could be complemented with market-forming demonstrators (e.g. for UK-sourced material flows and recovery, e.g. copper, aluminium, electric steel, magnets) and offtake agreements to de-risk investment in new UK mid-stream activities (e.g. local refining, power-electronics components, battery and magnet recycling). Enlarging the perspective to include reliable access to low-carbon energy and to inform grid build-out in line with the demand for the UK automotive sector could be specific opportunities to investigate in a dedicated research effort further.

4.6 The data traceability and forward-looking scenario exploration opportunity

Data transparency and forward-looking scenario exploration involves building up a material-focused national data observatory across automotive material flow streams, including reverse revalorisation options across different levels of tiers¹⁰. This can be achieved by engaging in collaboration across public and private sectors for pre-competitive data pooling and establishing a common auditing system for upstream supply chain inputs. The 'what' in this opportunity is improving data transparency, the 'why' is to reduce supply chain risks and improve resilience, and the 'how' is through building up a national data observatory and collaborating with public and private sectors. Members of the APC roundtable on resilience highlighted that identification of critical components through strategic supply-chain mapping and robust supply-chain modelling capabilities across UK suppliers would be an

important capability to improve the resilience of the UK automotive sector. By building this capability, the industry can gain a better understanding of its material usage and waste generation, identifying opportunities for reduction, reuse, and recycling as well as identifying opportunities for more closed- and open-loop collaboration

4.7 Supply chain connectivity and demand signalling opportunity

Another opportunity is supply chain connectivity and demand signalling, which involves improving coordination across UK-based supplier tiers by establishing a hub and coordination mechanism around dedicated component or material sprints. This can be achieved by agreeing on demand signals and bundling and dedicating deep-dive projects on selected component/material flows. The what in this opportunity is improving supply chain connectivity, the why is to reduce supply chain risks and improve resilience, and the how is through establishing a coordination mechanism and dedicating deep-dive projects. For instance, understanding and quantifying demand for minimum viable product volumes (e.g. for UK-based electric arc furnaces, 3 million tons of harvested feedstock) could trigger initiatives to map out which local revalorisation technologies could become economically viable, with automotive as a lead contributor and potential adjacent complementary industries. Developing such foresight and demand pooling across the APC constituency and members of the UK automotive sectors could be a local hedge to navigate global volatility.

4.8 Break-through funding and systemic capability building opportunity

Finally, break-through funding and systematic capability building involve setting up dedicated accelerator and funding programs to encourage faster adoption of research into practice, and rapidly changing technology bases and higher demands on process technologies could be systematically monitored to identify SME/startups to close capability gaps. The 'what' in this opportunity is providing break-through funding and building capabilities, the 'why' is to improve resilience and reduce supply chain risks, and the 'how' is through setting up

10. Hopkinson, P. et al. (2025) Circular Economy Data Observatory light passenger vehicles final report: Material flow analysis (MFA) focusing on light passenger vehicles in the UK (RDE807). Circular Economy Data Observatory (CE-DO) project, University of Exeter, on behalf of Defra Circular Economy Science: Strategic Evidence and Analysis.

dedicated accelerator and funding programs. From a policy point of view the implementation of supporting legislation could further accelerate the build-up of UK-based capabilities and encourage the formation of anchor projects to achieve faster higher levels of technology readiness levels (TRL).

4.9 Improvement of financing and funding regime opportunity

A critical, but currently underdeveloped, dimension of material risk mitigation relates to financing constraints across the midstream and upstream segments of the value chain. While many of the proposed interventions—such as domestic processing, recycling infrastructure, and material substitution are technically feasible, their implementation is often limited by structural investment challenges.

First, midstream processing and recycling facilities are typically highly capital-intensive, requiring substantial upfront investment (CAPEX) with long development timelines. These projects often face uncertainty in future demand, technology pathways, and regulatory standards, which reduces their attractiveness to private investors.

Second, there is a structural risk–return mismatch. Many of these investments generate positive system-wide benefits, such as supply chain resilience, reduced import dependence, and lower lifecycle emissions, but these benefits are not fully captured in private returns. As a result, purely market-based investment is often insufficient to scale these activities at the pace required.

Third, this creates a role for blended finance and public sector intervention. Instruments such as public co-investment, guarantees, offtake agreements, and demand aggregation mechanisms can help

de-risk early-stage investments and improve bankability. In particular, institutions such as the Advanced Propulsion Centre (APC), the National Wealth Fund, and UK Export Finance could play a catalytic role in mobilising private capital towards strategically important material value chains.

Addressing these financing constraints is therefore essential to translating technical and industrial opportunities into deployable solutions, and should be considered a core component of UK material resilience strategy.

4.10 ESG-roadmap orchestration and forward-looking management

This initiative involves the development of a comprehensive roadmap for the integration of Environmental, Social, and Governance (ESG) considerations into the UK automotive sector. Most of the interview partners mentioned initiatives at pan-national level (e.g. Drive Sustainability , World Auto Steel , Catena-X) with a sectorial or material focus. However, no equivalent forum for a UK-specific initiative was mentioned. Developing a more UK-focused initiative was considered as a potential addition to ensure the identification of specific needs and integration into the UK-focused policy and regulatory debate (e.g. regarding carbon-accounting, Environmental Product Declarations (EPD) initiatives). APC could consider building up a national supply chain and ESG-risk exposure toolkit as a unified system for mapping critical materials and components against key ESG risks. This could inform policy makers and UK automotive actors, and, in collaboration with global initiatives, support decision making for incoming regulations and their local adoption into the UK legislative landscape.

11. <https://www.drivesustainability.org/>

12. <https://www.worldautosteel.org>

13. <https://catena-x.net/use-case-cluster/sustainability/>

5 Conclusion

In conclusion, the research questions posed at the outset of this study have been yielding valuable insights into the material risks beyond EV batteries and REE traction motors in the UK EV industry.

Are there critical materials beyond EV batteries and REE in traction motors?



The first research question, “**Are there critical materials beyond EV batteries and REE in traction motors?**”, has been affirmatively answered, with the identification of a significant number of materials that are pivotal to delivering the performance needs of EV cars, yet have not received sufficient attention in academic research and public discourse. There are REE traction motors, as well as uses of REE in electronics, throughout the vehicle and these have the same security of supply concerns for those Tier 1 suppliers as the main traction motors. They have closely integrated electronics and motors and are even more difficult to recycle because they are distributed throughout the vehicle in hard-to-reach positions that make it hard to extract them profitably using current processes.

What are the main risks in the (upstream) value chains for critical materials and components?



The second research question, “**What are the main risks in the (upstream) value chains for critical materials and components?**”, has highlighted the relevance of various risks, including geopolitical and trade-induced risks, operational and supply chain risks, regulatory ESG and decarbonisation pressures, financial, pricing and volatility risks, and material quality and consistency risks. While OEMs and their (UK-based) suppliers know their bill of materials well, as they design the parts and have access to international databases, the understanding of the upstream supply chains of the components and materials is less developed, especially for materials beyond EV batteries and REE-PM traction motors. One of the main concerns is about lowering carbon footprint and meeting mainly EU and other regulatory requirements. Steel and aluminium alloys and polymer main components of the body and chassis are particularly important in decarbonisation.

What are the major gaps in the mitigation of the identified risks?



Finally, the third research question, “**What are the major gaps in the mitigation of the identified risks?**”, has led to the proposal of several initiatives, including midstream processing and material circularity, supply chain connectivity and demand signalling, systematic search for substitution and alternative sources, data transparency, and forward-looking scenario exploration, which can be leveraged to improve resilience and reduce supply chain risks in the UK automotive industry. By addressing these research questions and proposing solutions, this study provides a foundation for strengthening the UK-based automotive and supporting industries, ultimately contributing to a safer, smarter, and more sustainable transport solution.

The proposed recommendations outlined in this report suggest several initiatives for the UK automotive industry to mitigate material risks and strengthen its resilience. The Advanced Propulsion Centre (APC) has a critical role to play in translating these recommendations into tangible actions, by facilitating pre-competitive collaboration among industry stakeholders, providing funding and support for research and development projects, and promoting the adoption of best practices in supply chain management and risk mitigation. Some of these initiatives include the following (see full list in the recommendation section):

- **There may be a UK opportunity to use metals from domestic primary supply:** tin from near-term production, copper from projects at exploration stage, and tungsten in associated manufacturing tools. Work is needed to join up the supply chains.
- **There is very little ecodesign ready for re-use or recycling.** This is hard to do because of the reliability demands of the industry, which is therefore conservative in nature but an area with much scope.
- **There is little post use Circular Economy revalorisation and recycling capacity in the UK** so even when they are recovered, scrap materials are exported and together with re-use and remanufacturing initiatives this is also an area of opportunity. This highlights a potential misalignment where offshoring of material processing may reduce reported UK emissions, without necessarily reducing global emissions.

- **There is a need for data pooling, mapping for material- and component flows for the UK automotive sector** and detailed risk monitoring, especially as there are, for example, electronics including power electronics throughout EVs, with a suite of elements deemed highly vulnerable to supply disruptions. Almost all are manufactured overseas with long and opaque supply chains back to the original materials. Moves towards autonomous vehicles will increase this trend.

By working closely with industry partners, academia, and government agencies, the APC can help to accelerate the implementation of these initiatives, address existing capability gaps, and foster a more resilient and sustainable UK automotive industry.

Specifically, the APC can support the development of midstream processing capabilities, facilitate data pooling and scenario planning, and promote the adoption of circular economy principles, among other initiatives. By doing so, the APC can help to ensure that the UK remains a competitive and attractive location for automotive manufacturing, while also contributing to the country's net-zero ambitions and sustainable economic growth.



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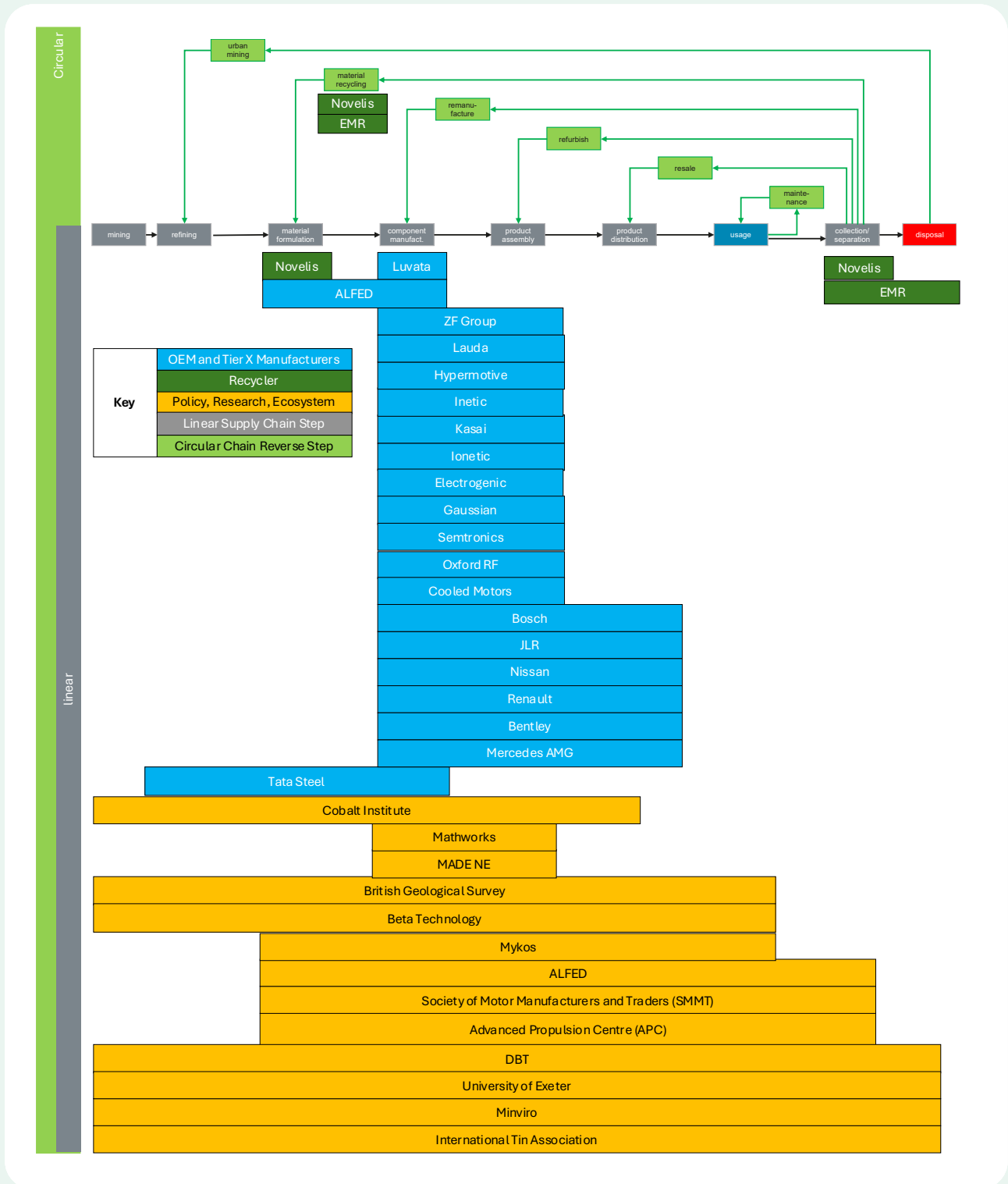
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6 Appendix

7.1 Overview of contributing entities

Figure 10 Supply Chain schematic and positioning of contributing entities.



6 Appendix

Figure 11 Overview of incoming regulation – selection

Regulation & Jurisdiction	Description & Intent	Timeline	Potential Impact on UK Automotive Sector
Corporate Sustainability Reporting Directive (CSRD) - EU	Replaces the NFRD to modernise and expand ESG reporting, requiring detailed disclosures on environmental and social impacts via European Sustainability Reporting Standards (ESRS). It mandates double materiality and a Paris-aligned net-zero transition plan.	Phased implementation. First reports due 2025 (for FY 2024). Listed SMEs must comply from Jan 1, 2026, with all in-scope companies reporting by 2028.	OEMs: Must track and publicly report Scope 3 emissions across their entire upstream supply chain. Tier-X & Local Materials: Will face intense data requests from OEMs regarding their carbon, energy, and labor footprints. Failure to provide accurate ESG data will result in losing contracts with EU-exposed OEMs.
Corporate Sustainability Due Diligence Directive (CSDDD) - EU	Mandates companies to identify, prevent, and mitigate adverse human rights and environmental impacts throughout their direct and indirect global supply chains.	Entered force July 2024. Phased application starts July 26, 2027 for the largest firms (>5000 employees), expanding to smaller firms in 2028 and 2029.	OEMs: Bear legal liability and face fines up to 5% of global turnover for deep-tier supplier violations. Tier-X & Local Materials: Subject to strict audits and mandatory contract updates. Material suppliers must establish internal processes to prove their operations are free from environmental and human rights abuses.
Deforestation Regulation (EUDR) - EU	Bans specific commodities (including rubber and cattle/leather) from the EU market if they were produced on land deforested or degraded after December 31, 2020.	Postponed to apply from Dec 30, 2026 for large/medium operators, and June 30, 2027 for micro/small operators.	OEMs/Tier-1s: Face massive compliance hurdles for tires (natural rubber) and luxury seats (leather), risking border delays or bans. Tier-X & Local Materials: Must complete due diligence statements providing precise geolocation coordinates of where their raw commodities were produced.
Carbon Border Adjustment Mechanism (CBAM) - EU & UK	Imposes a carbon price on imports of highly carbon-intensive goods (e.g., steel, aluminium) to prevent "carbon leakage" to countries with weaker climate rules.	EU: Definitive phase starts Jan 1, 2026 (certificates required by 2027). UK: Takes effect Jan 1, 2027.	OEMs: Face increased costs for imported raw materials from regions with low carbon pricing. Tier-X & Local Materials: UK steel and aluminium suppliers exporting to the EU must calculate and report embedded emissions to avoid heavy certificate costs. Conversely, the UK CBAM may protect local producers from cheap, high-carbon imports.

Continued overleaf

Figure 11 continued

<p>End-of-Life Vehicles Regulation (ELVR) - EU</p>	<p>Replaces existing directives to mandate vehicle circularity. It introduces binding targets for recycled content and requires vehicles to be designed for easy component removal and recycling.</p>	<p>Currently a proposal. Recycled plastic mandates will be phased over 10 years (15% within 6 years, 25% within 10 years of entry into force).</p>	<p>OEMs: Must radically redesign vehicle architectures to allow for the recovery of raw materials.</p> <p>Tier-X & Local Materials: Creates massive demand for secondary materials. Local plastics and metal suppliers must scale recycling infrastructure and chemical recycling technologies to supply the mandated recycled content.</p>
<p>Forced Labour Regulation (FLR) - EU</p>	<p>Prohibits the placing, making available, or exporting of any products made with forced labor on or from the EU market.</p>	<p>Entered force Dec 13, 2024. Fully applicable from Dec 14, 2027.</p>	<p>OEMs: Must conduct deep-tier due diligence (especially in high-risk mineral extraction regions).</p> <p>Tier-X & Local Materials: Must train employees, map supply chains, and assign responsibilities to ensure no forced labor taints their inputs, risking complete product withdrawal and disposal by EU authorities if found non-compliant.</p>
<p>Ecodesign for Sustainable Products Regulation (ESPR) & Digital Product Passport (DPP) - EU</p>	<p>Sets ecodesign requirements (durability, recyclability) and mandates a Digital Product Passport (DPP)—a digital identity card storing a product's lifecycle sustainability data, origin, and materials.</p>	<p>Adopted 2024. Phased rollout: iron/steel in 2026, batteries (under separate regulation) by 2027, aluminium/tyres by 2027.</p>	<p>OEMs: Must manage end-to-end digital records for vehicle components.</p> <p>Tier-X & Local Materials: Must implement data infrastructures to trace and share material composition and carbon footprints digitally (via QR codes/RFID) with downstream partners.</p>
<p>Sustainability Disclosure Requirements (SDR) - UK</p>	<p>Standardises corporate sustainability disclosures, aligning closely with global ISSB standards (IFRS S1/S2) to combat greenwashing and improve transparency.</p>	<p>UK Sustainability Reporting Standards (UK SRS) due Q1 2025, effective for accounting periods from Jan 1, 2026.</p>	<p>OEMs: Will be required to publicly disclose climate-related financial risks, transition plans, and supply chain impacts.</p> <p>Tier-X & Local Materials: Must align their environmental tracking with ISSB standards to provide the primary data OEMs need to remain compliant and secure green financing.</p>
<p>Plastic Packaging Tax (PPT) Updates - UK</p>	<p>Taxes plastic packaging containing <30% recycled content. Upcoming changes incorporate a mass balance approach (MBA) and remove pre-consumer waste from qualifying toward the threshold.</p>	<p>Rate increases to £228.82/tonne in April 2026. Pre-consumer waste exclusion takes effect April 2027.</p>	<p>OEMs & Tier-X: Will face higher costs for component logistics packaging if not compliant.</p> <p>Local Materials: Plastic producers relying on internal scrap to meet the 30% quota must pivot toward post-consumer recyclates or chemical recycling, requiring supply chain adaptation and strict certification.</p>

6 Appendix

7.2 Rapid vulnerability to supply disruption assessment for global automotive critical raw materials

A sector-specific screening of materials used across the EV bill of materials was conducted, building on the component taxonomy described in Section 2.1. The screening combines:

- Literature on EV architecture and component material composition
- Cross-referencing against critical minerals lists (UK¹⁴, EU¹⁵, US¹⁶, Australia¹⁷, Canada¹⁸), assigning a frequency score (1–5) weighted by automotive relevance (1–3), producing a combined score of 1–15
- Industry interviews and stakeholder discussions

Materials exceeding a threshold score of 6 were selected, ensuring both widely recognised critical

materials and automotive-relevant “runner-up” materials were captured.

The resulting material set extends beyond battery-focused discussions and includes both high-volume structural inputs—such as aluminium, copper and steels—as well as smaller-volume but functionally critical materials used in power electronics, sensing technologies and specialised alloys (e.g. gallium, tin, scandium).

A structured scoring framework was applied to assess relative criticality across a consistent set of risk dimensions. The framework combines quantitative indicators derived from the CMIC assessment (Table 9) with additional criteria defined through project-specific expert judgement. CMIC scores were rescaled from 1–10 to a 0–3 system, with adjustments applied where sector-specific considerations indicate higher exposure.

Design Criterion	CMIC Indicator	Description
Geographic concentration of supply	PCI	Measures how concentrated global production is
Geopolitical trade risk	GTC	Exposure to trade disruption and geopolitical leverage
Processing and refining concentration	R	Concentration of midstream processing capacity
Recycling / circularity constraints	EoLRR	Degree of supply from recycling
UK import dependence	NIR	Reliance on imports
Co-/by-product dependence	C	Supply constrained by co-production
Geological scarcity	–	Availability in the Earth’s crust
Market size and price volatility	–	Exposure to price fluctuations
Substitution difficulty	–	Technical and economic feasibility of replacement
ESG constraints	–	Environmental and regulatory pressures
Demand growth and sector competition	–	Competition from other sectors
Use in other industries	–	Cross-sector dependence

Table 1 Criteria defined by the CMIC (2024) and the authors as risk criteria impacting the UK critical mineral supply

14. British Geological Survey, Critical Minerals Intelligence Centre (2024) UK criticality assessment. Open Report OR/24/O4.

15. European Commission (2023) Proposal for a regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials (Critical Raw Materials Act). https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en#fifth-list-2023-of-critical-raw-materials-for-the-eu

16. U.S. Geological Survey (2025) About the 2025 list of critical minerals. Available at: <https://www.usgs.gov/programs/mineral-resources-program/science/about-2025-list-critical-minerals#CurrentStatus>

17. Australian Government Department of Industry, Science and Resources (2023) Critical minerals strategy 2023–2030. Available at: <https://industry.gov.au>.

18. Government of Canada (2022) Critical minerals: an opportunity for Canada. Available at: <https://www.canada.ca/en/campaign/critical-minerals-in-canada/critical-minerals-an-opportunity-for-canada.html>

6 Appendix

Each material was scored from 0 to 3 across all criteria (0 = low, 1 = slight, 2 = medium and 3 = high risk). Where materials were not included in the CMIC assessment, the same scoring approach was applied using available literature (e.g.¹⁹) and expert judgement, ensuring consistency across the material set.

The screening and scoring identify a broader set of materials contributing to supply chain risk within the UK EV sector. While battery materials and rare earth magnets remain well recognised, additional materials embedded across vehicle subsystems exhibit comparable or emerging risk characteristics.

These materials span both high-volume structural inputs and lower-volume, functionally critical materials. High-volume materials (e.g. aluminium, copper) are associated with system-level risks linked to energy intensity, demand growth and global market dynamics. In contrast, smaller-volume materials (e.g. gallium, germanium, tin, scandium) present risks associated with concentrated supply chains, limited substitution options and reliance on by-product production. Almost all materials share common UK-specific risks such as import dependence, alongside global risks such as cross-sector competition and demand growth. Material risks are not evenly distributed across the vehicle but are concentrated within specific components and subsystems. Supply disruptions are more likely to emerge within Tier 2 and Tier 3 components before propagating to OEM-level production, reflecting limited visibility of upstream material dependencies.

Material	Scores	Rank	CMIC score
Germanium	34	1	6
REEs	34	1	6.2
Gallium	33	2	5.3
Scandium	33	2	6.2
Indium	31	3	4.3
PGM	31	3	5.6
Tellurium	31	3	4.4
Phosphorus	30	4	5.8
Tantalum	29	5	4.4
Tungsten	29	5	5.4
Niobium	28	6	6.6
Silicon	27	7	5.3
Tin	27	7	4.5
Titanium	27	7	4.7
Magnesium	25	8	5.8
Nickel	25	8	4.3
Chromium	24	9	3.6
Copper	23	10	3.4
Vanadium	22	11	5.2
Iron	21	12	4
Manganese	21	12	4
Aluminium	20	13	4.2
Zinc	18	14	4

Table 2 Supply chain vulnerability rapid assessment for automotive elements that are included on several critical lists, with CMIC UK 2024 criticality score comparison column.

19. U.S. Geological Survey (2026) Mineral commodity summaries 2026 (ver. 1.1, March 2026). Reston, VA: U.S. Geological Survey. Available at: <https://doi.org/10.3133/mcs2026>



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