Scottish Enterprise

Critical Minerals: Scotland's path to economic resilience

Insights paper 2026

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The hidden foundations of our future

Imagine a world where the latest smartphones, electric cars, and renewable energy are no longer everyday essentials - they're harder to source and more expensive to deliver. Not because innovation has slowed, but because the building blocks that make them possible have become scarce. Beneath the surface of modern technology lies a fragile foundation - critical raw materials. Minerals such as lithium, cobalt, nickel, and rare earth elements, once overlooked, now quietly power everything. They are the lifeblood of our economy, shaping cost structures and supply chains.

As availability becomes increasingly uncertain, Scotland faces a new reality - technologies that once scaled effortlessly may now be constrained by the smallest components.

Our growing dependence on these materials for modern life brings new challenges: geopolitical tensions, environmental trade-offs, and looming supply risks. Their supply is fiercely contested and strategically concentrated - making them a focal point in the next global power shift. Should Scotland continue to rely on fragile, global supply chains, or do we reimagine how we source, recycle, and substitute these materials to build resilience? The race for Critical Raw Materials (CRMs) is intensifying. For Scotland, the question is no longer if we need to act, but how we respond - how we build the resilience needed to thrive in a rapidly changing world.

But before we can build that resilience, we must first confront the reality of where we stand today.

From vulnerability to vision

Our reliance on imported CRMs makes Scotland less resilient to future supply shocks in their availability. The hydrogen sector faces a two-year wait for electrolysers[1], the aerospace sector has had to ground aircraft[2] due to shortages, and manufacturers report up to seven-year delays for automation equipment. These are not distant hypothetical threats - they are present-day constraints on growth and innovation. According to McKinsey, 90% of companies have faced supply chain disruption[3], yet only a quarter have formal processes to assess risk at board level.

But within this vulnerability lies Scottish Enterprise's vision: a future built on Scotland's industrial history, natural resources, and vibrant innovation ecosystem. These foundations position us uniquely to turn risk into opportunity. We have the assets, the expertise, and the ambition to redefine our role in the global critical materials economy - building resilience for the challenges ahead.

Of course, Scotland is not alone in recognising the scale of this challenge. Across the world and here in the UK, there is a growing sense of urgency - and a new national strategy is setting the ambition for the UK.

A new national context: The UK's critical minerals strategy

The UK Government's new Critical Minerals Strategy[4] marks a step change in ambition, setting out a comprehensive approach to securing the minerals and metals essential for the net zero transition, competitiveness, and national security. It calls for greater domestic capability, robust data, and international partnerships, whilst recognising the role of regional strengths.

For Scotland, this is both a challenge and an opportunity. We should not simply align with the UK's direction but actively define our role within it. By leveraging our distinctive strengths, Scotland can position itself as the UK's centre of excellence for sustainable CRM solutions – becoming an active delivery partner for the national strategy.

What is Scotland's real differentiator? More than plans and frameworks, it's our strengths that set us apart.

Scotland's distinctive edge: Beyond the commodity mindset

Scotland's advantage lies not only in our geology and industrial infrastructure, but in our exceptional ability to reinvent and adapt. Our edge comes from eight world-class universities and eight innovation/research centres currently driving CRM research and impact, combined with a strong industrial base and a culture of circular innovation. The country also benefits from a diverse range of assets - such as decommissioned oil platforms and retired wind turbines - that offer unique opportunities for repurposing and value creation.

Innovation is already thriving across Scotland's value chain with more than 600 employees working in companies that Scottish Enterprise has so far identified. WEEE Scotland[5] leads the way in circular economy practices, transforming waste streams into valuable resources and generating high-quality jobs. Academic projects, including NEXGENNA's[6] development of sodium-ion batteries, showcase Scotland's commitment to finding alternatives to conventional critical raw materials. At the University of Edinburgh[7], researchers are pioneering biological techniques to recover metals like lithium, cobalt, manganese, and nickel from spent batteries, advancing sustainability and supporting the circular economy.

From industry to academia, Scottish organisations are innovating, strengthening our position and unlocking new opportunities for growth and resilience (see Fig 1).

The scale of opportunity before Scotland is significant. Achieving our offshore wind ambitions alone will require more than 3.5 times the critical raw materials currently in use (Annex 2). By remanufacturing just ten key turbine components, Scotland could unlock £10 billion in value and support over 20,000 jobs by 2035 [8]. These figures are more than statistics - they represent the seeds of a new industrial era for Scotland.

So, how do we turn this potential into reality? Scottish Enterprise believes it comes down to a framework with six key enablers.

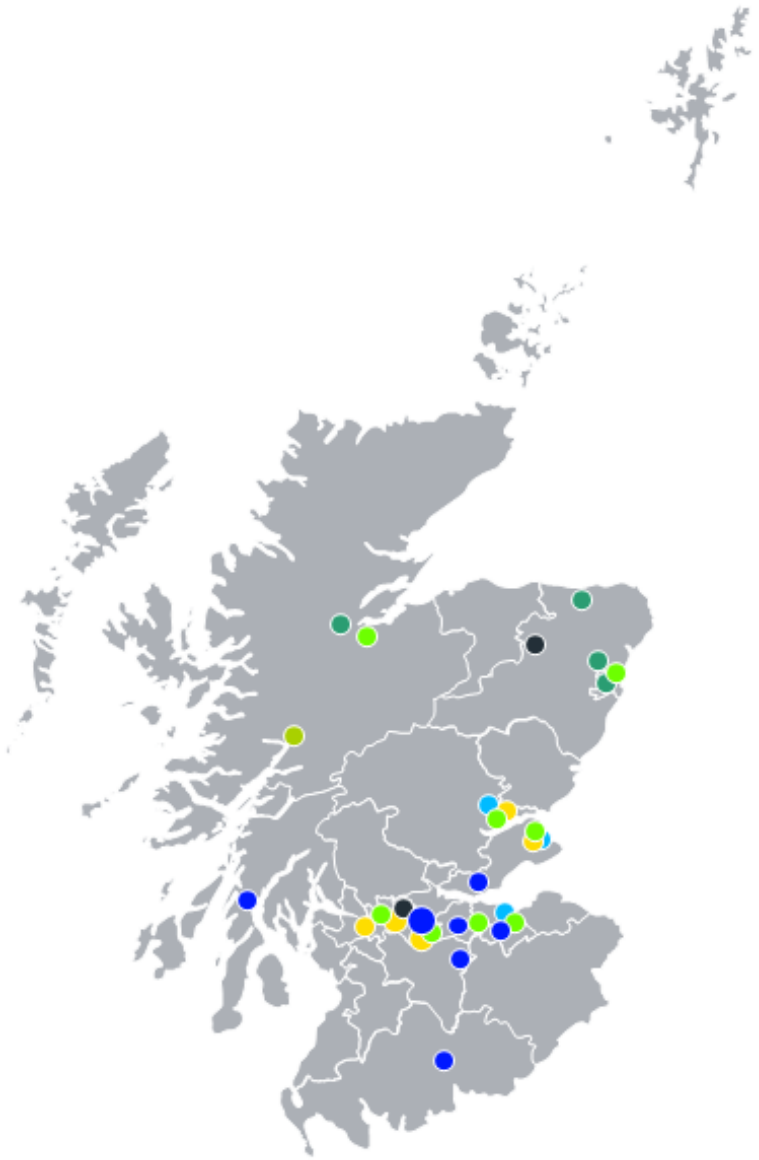


Fig. 1: Scottish Critical Raw Material Value Chain
(company details in Annex 1)

The six enablers: Scotland's blueprint for transformation

Moving from aspiration to action requires a clear plan. Scottish Enterprise believes that Scotland could embrace a framework of 6 enablers (Fig.2):

- **Research:** A national roadmap, targeting priority materials and closing knowledge gaps.
- **Innovation:** Bridge the lab-to-market gap with accelerators and demonstrators that speed adoption at scale.
- **Data:** Build digital infrastructure for traceability and transparency to strengthen investor confidence and supply chain resilience.
- **Policy and Regulation:** Streamlined and timely regulation, targeted incentives, and circular procurement would create the right conditions for investment and growth.
- **Investment:** Unlock co-investment models and long-term capital strategies to scale solutions.
- **Collaboration:** Joint approach across stakeholders to drive coordination and deliver impact.

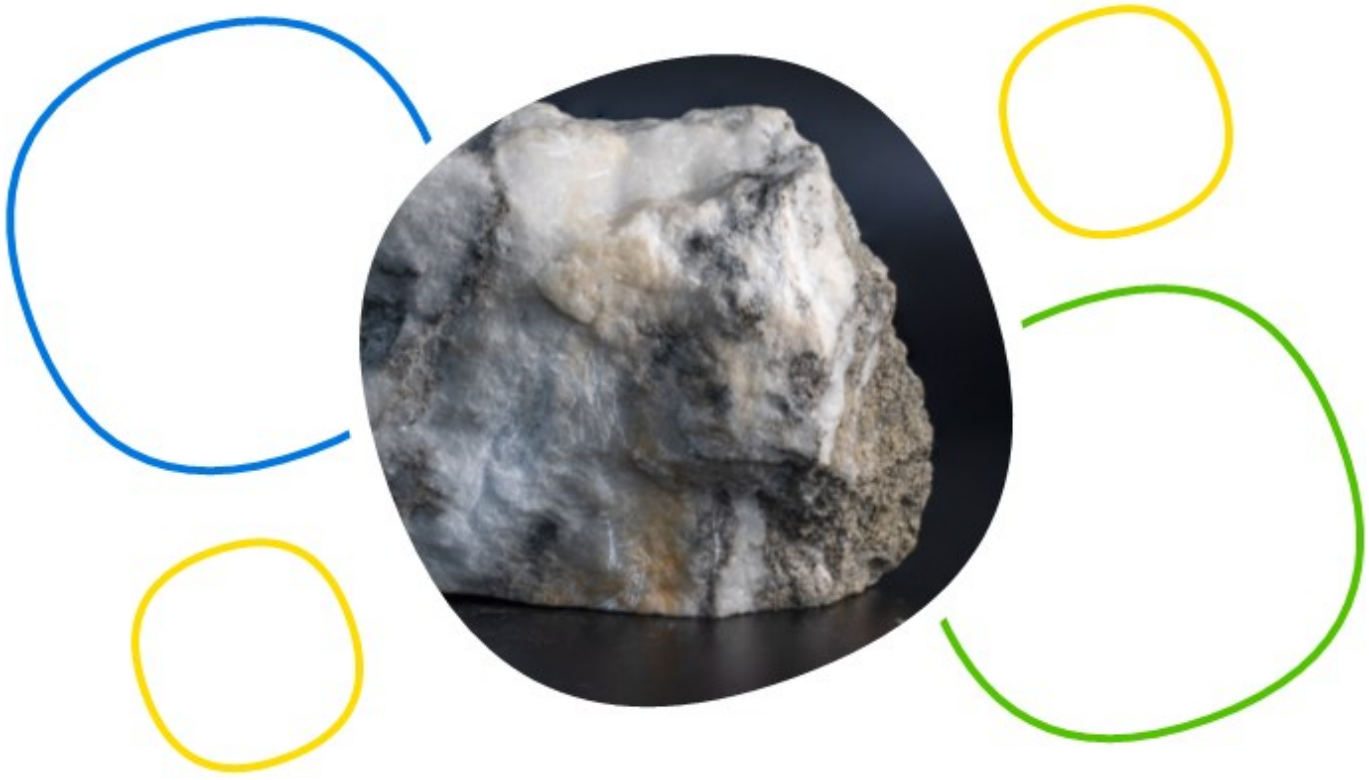
Fig. 2: Scottish Enterprise Solutions Framework

This framework sets out how a coordinated, ambitious national effort could create transformational change. And we are already off the starting blocks - across Scotland companies are already showing what's possible.

Pioneers across the value chain

Scottish Enterprise is supporting ambitious companies that are redefining what's possible in the critical raw materials sector. Cellmine[9] is revolutionising battery recycling, benefitting from both Scottish Enterprise's innovation and account management support. CoNi[10] is developing a new method for extracting cobalt and nickel, guided by our high growth spin-out team. Renewable Parts[11] and ReBlade[12] are extending the lifespan of wind turbine components and transforming waste into valuable new materials, each receiving tailored account management and specialist support. Evolve Metals[13] is planning to establish the UK's first copper refinery in decades, aiming for a closed-loop supply chain, and Scottish Enterprise is working closely with partners to help bring this project to fruition. Aberdeen Minerals[14], meanwhile, is exploring the extraction of critical raw materials in Aberdeenshire and is also account managed, further strengthening Scotland's position across the value chain.

These are Scotland's new generation of innovators - clear evidence that when innovation is nurtured and mainstreamed, it delivers economic and environmental value. However, to unlock Scotland's full potential, we should be honest about the barriers that exist.



Removing barriers to progress

Scotland's data on feedstock availability, supply chain transparency, and material flows remains patchy and insufficient to plan at scale. Addressing these gaps would reduce uncertainty and increase investor confidence to support our economic future.

As part of this, Scottish Enterprise, in collaboration with the Scottish Government through the Centre for ClimateXChange[15] (CXC), is actively supporting research to identify and understand the CRMs essential for Scotland's energy transition. This joint effort ensures that Scotland's shift towards clean energy is guided by robust evidence, targeted innovation, and a clear strategy for securing the necessary materials. By working together, Scottish Enterprise and the Scottish Government are helping to build the knowledge base. This approach demonstrates the benefits of strong collaboration to create a resilient, future-ready economy.

Building on this collaborative approach stakeholders across Scotland could support the development of robust digital traceability systems and a comprehensive national CRM data framework. This would allow resources to be accurately mapped supporting our businesses and sharing best practice across the sector.

The EU's Critical Raw Materials Act (2024)[16] sets clear permitting deadlines up to 27 months for extraction and 15 months for processing and recycling supported by a single authority and priority status for strategic projects[17]. By contrast, Scotland has no statutory caps, and major projects often take 2–4 years to secure planning and environmental consents, especially where Environmental Impact Assessments and inquiries are required. Recent measures such as NPF4[18], the National Planning Hub[19], Masterplan Consent Areas[20] and environmental authorisations[21] are positive steps, but further streamlining and proportionate timelines could help to attract and retain companies in the CRM value chain. This would mirror what is set out in the UK Critical Minerals Strategy where service improvements will result in quicker timeframes and more flexible decision making in moving developers through the system in England and Wales[22].

Developing the right skills is critical in achieving Scotland's CRM ambitions. Evidence across the UK[23] shows urgent gaps in metallurgy, chemical engineering, process operations and recycling, highlighting the need for early engagement and stronger industry-academic partnerships. The UK Critical Minerals Strategy[24] and the EU Critical Raw Materials Act (2024)[25] both prioritise skills development, calling for training programmes and centres of excellence. Scotland could consider widening its skills and industrial strategies to ensure businesses can innovate, adapt and lead in this fast-changing CRM landscape.

But resilience isn't just a national ambition it is a business imperative.

Building resilience: The supply chain imperative

For companies, the message is clear - understanding your supply chain is no longer optional – it is essential. Businesses should map their dependencies, diversify sources wherever possible, and plan for disruption as standard practice. Increasingly, resilience will depend on digital traceability of materials and components, giving full visibility for the whole life cycle of a product. This isn't just good governance it is becoming a market requirement. For businesses aiming to sell into the EU, demonstrating compliance and transparency will be critical. The most resilient organisations will treat supply chain risk as a board-level priority, invest in end-to-end traceability, and build flexibility into their operations. In a world where shocks are inevitable, resilience and verifiable transparency is the new competitive advantage.

So, what does this mean for Scotland's future?

Seizing Scotland's strategic opportunity

Scotland has a unique opportunity to make significant progress, but doing so will require alignment with UK and EU priorities in ways that reflect Scotland's strengths. Businesses should invest in supply chain resilience, circular economy models, traceability, and workforce skills, while ensuring research delivers commercial impact.

Scottish Enterprise is focused on driving economic transformation through our three interlinked missions of **accelerating the energy transition** by attracting international investors and supporting domestic companies to grow in renewables supply chains, **scaling innovation** by supporting ambitious companies in future industries to scale here in Scotland and **boosting capital investment** by enabling businesses to attract capital into productivity increasing projects. Businesses and business models operating in these mission focus areas require a reliable access to CRMs. The challenge is significant, but the opportunity is even greater.

Whether you're an entrepreneur, an SME on a growth journey, an innovator, researcher, developer, investors or policy makers with an interest in CRMS, we want to hear your boldest ideas.

Connect with Scottish Enterprise and help turn today's challenges into tomorrow's opportunities. **We back ambition.**

Glossary and Chemical Symbols

Al –Aluminium
B - Boron
Co – Cobalt
Cr – Chromium
Cu – Copper
Dy – Dysprosium
Fe - Iron
Ga – Gallium
In - Indium
Li - Lithium
Mn – Manganese
Na - Sodium
Nd - Neodymium
Ni – Nickel
P – Phosphorus
PGM – Platinum Group Metals
Pt - Platinum
REE – Rare Earth Elements
Si - Silicon
Ta - Tantalum

References

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[2] British Airways scraps long-haul flights amid Rolls-Royce engines parts shortage | The Independent
[3] McKinsey Global Supply Chain Leader Survey 2024 | McKinsey
[4] UK critical mineral strategy vision-2035.pdf
[5] WEEE Scotland
[6] NEXGENNA
[7] University of Edinburgh
[8] Coalition for wind industry circularity
[9] CellMine - CellMine
[10] CONi – Critical metals sequester technology (HGSP Opportunity Qualification – CoNi Project ref: PS7305150) - University of Strathclyde
[11] Leading Supply Chain & Refurbishment Specialist in Wind Energy
[12] Reblade | Reblade
[13] www.evolvemetals.uk
[14] Aberdeen Minerals
[15] CXC
[16] EU Critical Raw Materials Act
[17] EU CRMA permitting
[18] National Planning Framework-4
[19] National Planning Hub
[20] Masterplan Consent Areas
[21] Environmental Authorisations
[22] UK critical mineral strategy vision-2035.pdf
[23] UK CMA - Skills
[24] UK critical mineral strategy vision-2035.pdf
[25] EU Critical Raw Materials Act

Annexes

Annex 1

An illustrative example of some of the businesses, innovation centres and academic institutions operating in Scotland, across the CRM value chain.

TYPE OF ORGANISATION/ KEY CAPABILITY	NAME	BRIEF DESCRIPTION	WHICH REE/CRITICAL MATERIALS
PROCESSING	Alvance British Aluminium	Only UK Al Smelter	Al
SUBSTITUTION/ DEMATERIALISATION	Nova Innovation	Tidal energy systems with rare-earth-free generators	REE
	Ceimig	Working to reduce the amount of PGM required for PEM electrolysers	PGM
	University of St Andrews	Sodium-ion battery R&D to substitute lithium-ion	Li
INNOVATION/ RESEARCH CENTRES	NMIS / AFRC (Strathclyde)	Modular manufacturing and materials testing	
	IBioIC	Bio separation to recover metals	Co, Li, Ni, Mn
	REACT Centre	Research centre for sustainable electronics with a focus on recycling and recovery of CRMs from end-of-life electronics	Various
	Centre for Medical and Industrial Ultrasonics (C-MIU)	Apollo Project – PV recycling and Reuse using ultrasound-based techniques	Si
	Colin Vincent Centre for Battery Technology	Next generation battery development	Various
	SUERC (Scottish Universities Environmental Research Centre)	Contributes expertise in isotope geochemistry for critical metal research.	Various
	Centre for Energy, Petroleum and Mineral Law and Policy (CEPMLP)	research is focussed on the role of law, economics and international politics on energy and natural resources industries. Research includes critical mineral value chains.	Various

TYPE OF ORGANISATION/ KEY CAPABILITY	NAME	BRIEF DESCRIPTION	WHICH REE/CRITICAL MATERIALS
	ReMake Value Retention Centre	Systems-level circularity in high-integrity sectors	
ACADEMIC CAPABILITIES	Heriot-Watt University	Low-impact extraction and dry separation techniques to efficiently recover CRMs from end-of-life lithium-ion batteries	Li, Co, Ni
	University of Glasgow	recycling and Reuse using ultrasound-based techniques	Si
	University of Edinburgh	Engineered microbes to extract and recycle rare and critical metals Selective and sequential precipitation of precious metal compounds from an aqueous acid solution supramolecular chemistry approach to recycling rare earth elements from magnet scrap	Various
	University of Strathclyde	Extraction of CRMs from water systems	Ni, Co, Cu
	University of St Andrews	Alternative battery chemistries	Battery metals
	University of Highlands and Islands	large-scale phosphorous recovery from wastewater using cost-effective adsorbents	P
	University of Dundee	Legal and regulatory frameworks for sustainable mining	
	University of Aberdeen	PhD in developing a mineral systems framework for North East Scotland	Exploration
	Training and Research Group for Energy Transition Mineral Resources	Scottish Universities include St Andrews University, University of Aberdeen, University of Edinburgh	Training and Research
RECYCLING & REPROCESSING	Evolve Metals	Waste copper refining and closed-loop supply chain	Cu
	WEEE Scotland	CRM recovery from e-waste	Cu, REE, Li, Co, Ni
	EMR	Recycling of Metals, End of life Vehicles, WEE and Cables with specialisms in: Renewables, Li-ion	A range incl: Li, Al, Fe, Cu etc

TYPE OF ORGANISATION/ KEY CAPABILITY	NAME	BRIEF DESCRIPTION	WHICH REE/CRITICAL MATERIALS
		battery recycling, marine structures and vessels	
	Cellmine	Battery recycling using sulphate-free, zero waste chemical process producing: high performance cathode materials	Li, Co, Ni, Mn, Al
	EGG Lighting	Extends the life of CRM-containing components (e.g. LEDs, drivers, sensors)	Ga, In, REE
	Renewable Parts	Repurposing parts of wind turbines	Various
	ReBlade	Repurposing and recycling composite materials, particularly glass-reinforced plastic	B
	FFS International	Expertise in recovery, purification, and industrial reuse	
	Proficio	Cleaning of and coating removals so alloys and metals can be reused	Various
EXPLORATION	Aberdeen Minerals Ltd	Exploration in Aberdeenshire	Ni, Cu, Co
	Bell Geospace	technology supports early-stage exploration	All mineral deposits
	Peak Nickel	Exploration in Aberdeenshire	Ni, Cu, Co
	Hebridean New Metals	Exploration in the Highlands	REE, Li, Mn
EXTRACTION	Nibeenabe	Extracts and reclaims metallic components from mine tailings	Cu and other minerals not deemed to be critical including gold, silver, mercury

Annex 2

Estimated quantity of critical raw materials required for offshore wind turbines

As of October 2024, there were 519 wind turbines in development and under construction. For the build out of INTOG and ScotWind there is an expectation that approximately 1800 wind turbines will be constructed. It is therefore estimated that INTOG and ScotWind would require approximately 3.5 times more critical materials, than projects currently in development or under construction.

The table below shows the estimated quantity of each material required to construct all the turbines in development or under construction at the time of writing (519 turbines).

	Nickel (Ni)	Chromium (Cr)	Copper (Cu)	Manganese (Mn)	Molybdenum (Mo)	Zinc (Zn)	Rare Earth Elements (REEs)	Aluminium (Al)	Boron (B)	Cobalt (Co)	Steel
~ Kg of material per MW installed	240	525	8,000	790	109	5,500	239	1,000	420	15	108,840
~ Tonnes* of material required for projects in development and under construction[1]	1,700	3,800	57,000	5,700	800	39,000	1,700	7,200	3,000	110	780,000
~ Tonnes* of material required for INTOG and ScotWind	6,000	13,000	199,000	19,700	2,700	137,000	5,900	24,900	10,400	370	2,700,000

*Figures rounded to the nearest 100
Variables: This data is approximate values only. Fluctuations will occur in quantity of material input required depending on type of wind turbine (e.g. floating, fixed) and energy generation capacity (e.g. MW).

[1] 519 turbines under construction and in development (as of October 2024) – with a MW range of 8.3 to 16

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