EXECUTIVE SUMMARY

ELLEN MACARTHUR FOUNDATION

LEADING THE CHARGE

TURNING RISK INTO REWARD WITH A CIRCULAR ECONOMY FOR EV BATTERIES AND CRITICAL MINERALS

FOREWORD

Electric vehicles are scaling fast, and with them, the batteries and critical minerals that underpin the transition. **This shift is creating major commercial opportunity, but it is also moving the automotive industry from fuel-centric to material-centric value chains**, exposing businesses and economies to price volatility, supply bottlenecks, and growing environmental and social risks.

Researched and written by the Ellen MacArthur Foundation, **this report sets out how a practical, structural, and system-level view of circular economy can reshape the EV battery economy** to unlock economic value while building resilience. It articulates a system-level vision framework in which batteries deliver the greatest possible mobility and energy services; are kept in high-value use through maintenance, repair, refurbishment, and remanufacture; and are ultimately collected and recycled at high quality so critical minerals never become waste.

This report translates this ambition into five reinforcing circular loops (from intensive use, life extension and cascading to second-life applications, high-quality recycling, and the information exchange that enables them) **and three levels of circular action**: product and component design, business models, and the wider systems of infrastructure, finance, and policy. Our vision framework has been informed by over 15 years of circular economy research, advocacy, and collaboration across public and private sectors, and in a wide array of sectors and industries.

Grounded in practical examples and 'bright spots' already emerging across the value chain, and **informed by direct engagements with stakeholders and leaders** across the EV battery value chain, it offers commercially focused recommendations for the EV battery industries and associated stakeholders — original equipment manufacturers (OEMs) and battery manufacturers, recyclers and logistics providers, energy and mobility players, policymakers, and investors — to accelerate a competitive, scalable, and fair circular battery economy. It distils the most decision-relevant levers to act on now, and provides a platform for organisations to deepen analysis and implementation in their own context.

Scope and intent

It is important to be mindful of scope. This report is not intended to be an exhaustive catalogue of every circular intervention, business mechanism, or policy instrument. The omission of specific approaches does not imply they are unimportant. In addition, this report intentionally does not replicate the quantitative forecasting and scenario modelling provided in critical minerals outlooks and recycling studies. Rather, **the report is written for a cross-value chain audience and prioritises commercially actionable themes** that can be advanced through collaboration, investment, and policy advocacy — and that can be strengthened by the Ellen MacArthur Foundation's circular economy expertise and convening role.

We see this publication as **one of the many early steps for the Ellen MacArthur Foundation in a multi-year campaign committed to accelerating a circular economy for critical minerals in the EV battery value chain.** Building from the bright spots highlighted here, we will work with partners, members, and wider stakeholders to develop deeper insights, sector-specific implementation pathways, and detailed proposals for industry collaboration, with the aim of mobilising further action at scale.

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Electric vehicle batteries: a growing strategic priority

Electric vehicle (EV) batteries are becoming the strategic asset class of the energy transition. As adoption accelerates, the automotive transition shifts from fuel-centric to material-centric vehicles. A typical EV, by some estimates, contains over 200 kg of critical minerals — around six times more than an internal combustion engine (ICE) vehicle. And, more specifically, EV batteries contain and are reliant on a wide range of valuable critical minerals, such as lithium, graphite, cobalt, and nickel.

However, today's EV battery value chain remains highly material-intensive, geographically concentrated, and structurally linear, creating systemic risks as demand grows. Potential supply shortfalls for key minerals, exposure to environmental and social harms, and challenges in mining, processing, manufacturing, and recycling could increase costs, destabilise markets, increase price volatility, and slow deployment. Together, these dynamics increase the fragility of the EV battery value chain precisely at the moment when the system needs to rapidly scale.

A systemic circular redesign is needed across the value chain. A broader redesign of products and components, business models, and the energy-mobility system is essential to strengthen resilience and reduce systemic risks. Scaling a circular EV battery transition therefore requires moving beyond incremental and end-of-pipe fixes towards a system-level redesign. One that generates economic value across the value chain, reduces material intensity, mitigates supply risks, and lowers environmental and social impacts.

The circular economy: turning risk into competitive advantage

A circular economy approach can convert these challenges into a competitive opportunity. By keeping batteries and the critical minerals in high-value use across multiple life cycles, and by designing the surrounding mobility, energy, data, and policy systems, a circular EV battery economy is economically viable at scale. For business leaders across the value chain, such an approach is not an add-on, but a board-level strategic lever to:

- **Protect margins** by increasing utilisation, extending battery life, and avoiding premature replacements
- **Reduce exposure** to volatile mineral markets and concentrated supply chains
- **Create new revenue pools and business models** by managing batteries and materials as assets (service, upgrade, second-life, and circular-mineral streams)
- **Strengthen resilience and licence to operate** amid geopolitical disruption and tightening regulation.

How critical minerals in EV batteries are sourced, used, and recovered determine the predominant value and risk for the EV value chain — making a circular economy a strategic imperative for industry leaders. Business decisions governing the management of these minerals — through strategy, business models, and design — will have profound impacts on both the commercial value businesses can capture, and the exposure they face to supply disruption, cost, and other risks across the EV battery value chain. As the EV market enters a phase of rapid scale-up, the window to shape these operating systems is now: early investment in circular economy approaches can offer the greatest opportunity to unlock resilience, competitiveness, and long-term value.

Moving beyond silos: towards a system-level strategy

The current circular economy narrative and efforts remain fragmented and often focused on end-of-life. Credible analyses on EV demand growth, mineral constraints, recycling capacity, and policy pathways have been developed, and industry action has been mobilised – mostly focused on recycling, and to a lesser extent second life. However, this narrow focus can crowd out meaningful, innovative, and high value-add levers that could be applied ahead of recycling. At the same time, issues with the supply-demand gap remain unaddressed in the short-term given the significant time lag between battery production and the end of the battery's first life, while disproportionate pressure is being placed on rapid recycling-infrastructure scale-up when a broader set of end-of-life solutions are not considered.

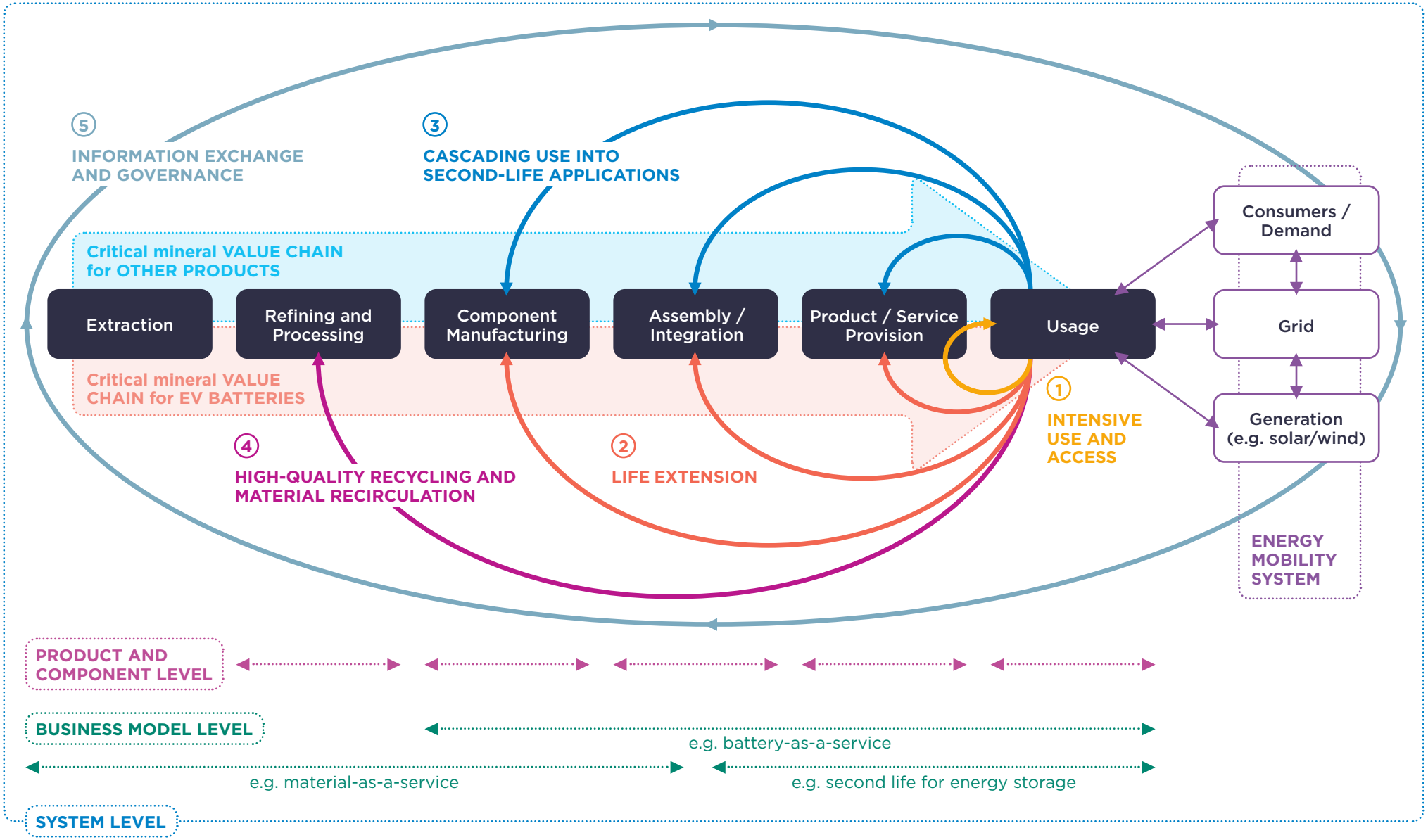
The circular economy vision set out in this report deliberately rebalances the conversation and ambition from end-of-life optimisation to system-level redesign. The economic benefits of the circular economy for EV batteries are realised through aligned and collective action between actors in the EV battery value chain, rather than through siloed efforts. The decisions made at each stage of the value chain can constrain or enable circular economy activity at every other stage. For example, upstream decisions on battery design and architecture, data access, and ownership determine how batteries can be practically circulated downstream. Similarly, market access, standards, and signals determine how well upstream players are able to innovate and invest in circular activities with confidence. The exact dependencies, trade-offs, and open questions will need to be modelled and tailored to local market and regulatory realities to enable business leaders and policymakers to effectively manage batteries and their critical minerals as the strategic assets they are.

The result is a commercially relevant framework that helps leaders turn circular economy ambitions from scattered pilots into a coherent value chain strategy, highlighting the tangible financial value and broader strategic upsides. It provides a common language for aligning investment, partnerships and capability building, and for identifying value leakage, risk accumulation, and the interventions that unlock the greatest system returns. The report translates this into action through two lenses:

1. **Five circular loops for EV batteries**, illustrating the 'inner loops' where highest value can be retained (intensive use, life extension, and cascading use), the 'outer loop' of high-quality recycling, and the overarching loop of information exchange and governance, which act as key enablers across the system

2. **Three levels of action** that bring the circular economy to life, presenting how circular thinking can be applied to create system-level change at each level:
   - Product and component design,
   - Business models, and
   - Systems

Figure 1 How the circular economy drives innovation and value creation across the EV battery critical minerals system



Mobilising system change: five bright spots for leadership action

Five major 'bright spots' — high-potential opportunity areas for cross-value chain collaboration — were identified based on insights gathered from value-chain stakeholders and real-world case studies. For each, the report sets out immediate first steps that relevant system actors can take to drive meaningful progress.

Leaders across the EV battery value chain can act now by focusing on five strategic actions:

1. **Design batteries for circularity, not disposal**
   Rethink EV batteries not as single-purpose assets, but as durable components of a broader mobility and energy system, intentionally designed to last, be taken apart, and reused in different applications across multiple lives. To achieve this, the system must build in modularity, safe disassembly/debonding, diagnostics, and traceability from day one, so repair, remanufacture, second life, and high-quality recycling are technically and economically viable at scale.

2. **Rethink battery service within optimised energy-mobility systems**
   Redefine battery value not as maximised capacity in every vehicle, but as delivering the right performance for the right use, with mobility systems designed to support access to services rather than ever-larger batteries. This can be achieved by moving away from oversized and over-specified products and towards rightsizing and optimising for real needs. This shift must be supported by the redesigning of the energy-mobility system to reset the 'default' expectations of vehicle requirements, and allow users to access more or equal functional utility through innovation in service models across the rest of the EV battery value chain.

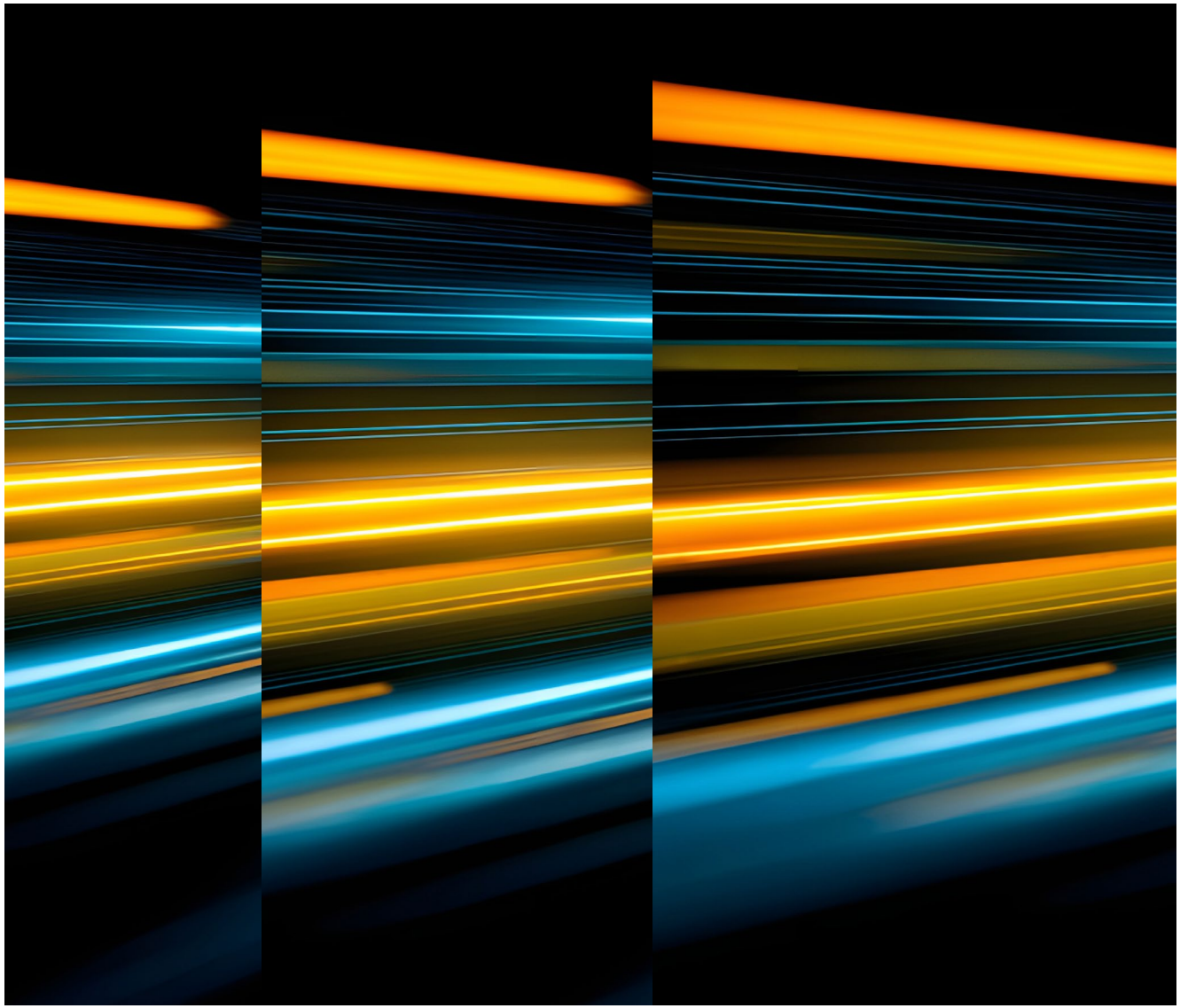
3. **Scale circular business models**
   Reframe batteries and materials not as products sold once, but as assets managed over time through models that reward durability, performance, recovery, and deployment into second-life applications, across multiple cycles of use. This includes expanding Battery-as-a-Service, upgrade/maintenance subscriptions, performance-based warranties, structured second-life offerings, and Material-as-a-Service pilots so durability, uptime, recovery, and residual value become commercial incentives and bankable outcomes rather than afterthoughts.

4. **Build and co-invest in regional circular infrastructure**
   Reimagine the battery value chain as an intentionally designed network of regional and inter-regional infrastructure that enables materials to circulate efficiently, resiliently, and transparently. This means treating collection, triage, testing/grading, repair/remanufacture, repurposing, and recycling as core infrastructure; and de-risking capacity via shared investment models and long-term feedstock/offtake contracts that make circular flows predictable.

5. **Make the circular operating system work**
   Reduce transaction costs and give businesses and investors the confidence to operate repair, reuse, and recycle loops at scale by creating the necessary transparency and traceability of currently hidden flows in the EV battery economy. This can be done by deploying interoperable battery passports and common data standards; aligning definitions and requirements (e.g. end-of-life classification, transport and treatment rules); and strengthening assurance mechanisms so secondary battery and material markets can function at scale with lower transaction costs and risk — going beyond compliance and structuring market infrastructure.

For 15 years, the Ellen MacArthur Foundation has aligned a powerful business and policy network around a vision of an economy that works differently. To catalyse implementation at scale the Foundation connects actors across value chains who can move quickly, learn, adapt, and sustain progress. In this context, we have already engaged over 30 EV battery industry actors representing each section of the value chain — from extraction and processing, to manufacture, service provision, and end-of-life reprocessing -- to develop a future-proofed circular economy vision for the sector. From our unique position at the intersection of business and policy, our aim is to drive three types of action in the EV battery value chain: setting clear direction and alignment for business action, of which this report marks an early step; enabling effective collaboration to mobilise investment and innovation through new, localised networks, joint ventures, shared infrastructure, and co-investment; and advancing collective advocacy to reshape the policy and regulatory conditions needed for a circular EV battery system to succeed.

Reframing EV batteries as high-value circular assets has the potential to be transformative. With a coherent view of where value is created or lost, where risks are accumulating, and which interventions unlock the greatest system-level returns, the industry can move beyond fragmented circular initiatives to build long-term resilience and value — protecting margins, shifting business models and profit pools, reducing supply exposure, and keeping critical minerals in circulation.



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ABOUT THE ELLEN MACARTHUR FOUNDATION

The Ellen MacArthur Foundation is an international charity that develops and promotes the circular economy in order to tackle some of the biggest challenges of our time, such as climate change, biodiversity loss, waste, and pollution. We work with our network of private and public sector decision makers, as well as academia, to build capacity, explore collaborative opportunities, and design and develop circular economy initiatives and solutions. Increasingly based on renewable energy, a circular economy is driven by design to eliminate waste, circulate products and materials, and regenerate nature, to create resilience and prosperity for business, the environment, and society.

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