Sustainable Lithium-ion batteries: Investor Briefing

May 2025

First Sentier MUFG
Sustainable Investment Institute

Read Report

01 | If you only have two minutes...

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The **lithium-ion battery market is expanding rapidly,** fuelled by rising demand for **electric vehicles** and **energy storage** — both essential for decarbonising transport and energy while reducing reliance on fossil fuels.

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As these sectors expand, demand for **lithium** and **nickel** are expected to surge **fortyfold** by **2040,** while **cobalt** and **graphite** could increase more than **twentyfold**. This will require a rapid scale-up of supply chains.

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Battery supply chains are not free of **environmental and social risks**, particularly in raw material extraction, processing, and end-of-life management. These include pollution, resource depletion, and human rights concerns, as outlined in Table 1a (overleaf).

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Governments are **tightening regulations**, with the **EU Battery Regulation** and **Battery Passport** leading the push for **transparency and responsible sourcing**. However, this **process is still evolving**, requiring realistic targets, safeguards for data privacy, and international cooperation to standardise regulations.

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The industry is adopting **circular economy principles**, driving the growth of battery recycling and second-life applications. While recycling will be vital in the long term, it is unlikely to scale before the 2030s. For the next 5–10 years, **battery production is expected to rely heavily on virgin materials.**

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Some challenges are deeply embedded in existing supply chains. **Innovations** such as **direct lithium extraction** or more efficient manufacturing techniques like **cell-to-pack technology,** may be essential to improving sustainability and efficiency.

Table 1a: Key summary of environmental and social risks at each stage of the battery value chain[i]

	Raw material extraction Mining of key minerals such as lithium, nickel, cobalt and graphite.	Material processing Raw materials are purified using thermal and chemical treatment.	Cell and pack manufacturing Cathode, anode, separator and electrolyte are assembled into a cell.	Battery installation Battery packs are installed into a product such as an EV.	End-of-life management At the end of their lifecycle, batteries are either re-used, recycled or disposed of
Environmental risks					
Air	H	H	H	M	H
Water	H	M	M	L	H
Soil	H	M	L	L	H
Biodiversity	M	M	L	L	M
Resource depletion	M	L	L	L	L
Hazardous substances	L	N	N	N	N
Social risks					
Fair working conditions	H	M	M	L	H
Community	H	L	L	L	L
	Highest risk				

Key: H High M Medium L Low N Limited Evidence in literature

Sources: IEA, Child Labour Platform, ILO, Harvard International Review, S&P Global Market Intelligence, Benchmark Minerals, Nature Reviews Earth & Environment, Reuters, USGS, Centre on Global Energy Policy, Global Battery Alliance, National Minerals Information Center, Global Witness, Financial Times, Bloomberg, Rainforest Rescue, RAID, Amnesty International, Faraday Institution, Geneva Center for Business and Human Rights, Human Rights Watch, WEF, IIED, and other; PwC Strategy& Analysis

In a complex value chain investors can act by:

- Advocating for greater corporate disclosure of ESG considerations, through better due diligence practices and encouraging more effective reporting.
- Encouraging corporate action to address ESG risks at every stage of the value chain
- Fostering partnerships with companies, investors, government, and NGOs to drive innovation, sustainability, and knowledge-sharing

This report provides investors with a comprehensive analysis of the sustainability risks and opportunities in the lithium-ion battery value chain.

[i] These risks reflect the organisation's impact on society rather than threats to its enterprise value. In the context of Double Materiality Assessments, as required by the CSRD, this represents the "inside-out" perspective, which examines how a company's activities affect environmental, social, or governance (ESG) factors. By contrast, the "outside-in" perspective considers how external ESG factors influence the company's financial performance.

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02 | About the Institute

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Acknowledgements

The Institute would like to thank the authors of this publication, Matt Alabaster, Alastair Scott, Avinash Rao, James Fulker, Luke Thomson, Harry Spirit, Ellen Huang, and Mathieu Lefeuvre from PwC Strategy&.

This document has been prepared with the support of PwC Strategy& as a research partner.

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03 | Executive Summary

Lithium-ion batteries play a pivotal role in the energy transition. These batteries can power electric vehicles and support renewable energy generation, as well as being used in consumer electronics and medical devices. As these sectors expand, the global demand for batteries is expected to significantly increase. However, the battery supply chain presents several environmental and social challenges that must be managed responsibly. Investors should be aware of these risks and consider strategies to mitigate them.

Lithium-ion (Li-ion) batteries are critical to the shift away from fossil fuels towards renewable energy. They will underpin the transition of the transport and power sectors, which together account for 60% of global greenhouse gas (GHG) emissions.[1] Electric vehicles (EVs) typically emit fewer GHGs over their lifetimes compared to traditional internal combustion engine vehicles[2]. In stationary energy storage, Li-ion batteries stabilise the grid by managing fluctuations from intermittent renewable sources like wind and solar. This helps balance energy demand and supply, facilitating the integration of renewables into the grid and reducing reliance on fossil fuels.

The most common Li-ion batteries are Lithium Iron Phosphate (LFP) and high-nickel Li-ion chemistries such as Lithium Nickel Manganese Cobalt Oxide (NMC) batteries. High-nickel batteries, which power over half EVs today, are popular for their high energy density, light weight, and fast charging capabilities.[2] However, LFP batteries, which captured 40% of the market in 2024, are increasingly favoured for their lower cost, greater safety, and longer lifespan.[2] In stationary energy storage where weight and size matter less, LFP is preferred compared to NMC, making up 80% of new installations in 2023.[1] This trend also reduces reliance on cobalt, often linked to human rights abuses in its supply chain.[3]

The surging demand for batteries is driven primarily by the rise in EV sales and the expansion of energy storage. According to the International Energy Agency (IEA), global EV sales are set to rise three- to fivefold by 2030, while installed battery storage could grow nine- to fourteenfold.[2] Meeting this demand requires steep increases in the extraction of lithium, cobalt, nickel, and graphite. In 2023, battery demand for lithium and nickel jumped by 30%, while cobalt demand rose by 15%.[2] By 2040, lithium and nickel consumption could increase over 40 times, with cobalt and graphite expected to rise more than 20 times.[2] Despite recent headwinds—driven by regulatory shifts and affordability challenges—EV adoption remains on track for long-term growth, with a largely electric fleet expected. Automakers are launching new models at lower price points and expanding production capacity in anticipation of this trend.

Every stage of the battery value chain poses environmental and social challenges particularly during mineral extraction. The world's critical minerals are often located in regions with varying levels of political stability and environmental and social regulation. Poorly regulated mining can lead to deforestation, soil erosion, and contamination of land and waterways, straining already scarce water supplies. This has been observed in South America, where lithium extraction has disrupted natural aquifers and contributed to water shortages for local communities.[4]

Refining and manufacturing also present significant challenges in waste treatment and emissions. These processes are energy-intensive and often rely on carbon-intensive electricity grids, particularly in China and Indonesia, where coal remains a prominent energy source. Additionally, refining can generate hazardous byproducts, such as sulphur dioxide and acid waste, which, if not properly managed, pose risks to both human health and the environment.

Social risks, including modern slavery and child labour, are widespread across the battery value chain, particularly in regions with weak regulatory oversight. In mining, hazardous conditions, such as exposure to toxic dust, cave-ins, and lack of protective equipment, pose significant health risks to workers. The situation is particularly acute in the Democratic Republic of Congo (DRC), where there are widespread reports of human rights violations and labour exploitation in the artisanal and small-scale mines (ASM).[3] More than 400,000 people in the DRC are trapped in modern slavery.[5] Beyond mining, refining and manufacturing also present dangers. Workers may be exposed to harmful chemicals and inadequate safety protocols have led to fatal accidents. Even in well-regulated jurisdictions, open-pit mining can displace communities and damage local ecosystems.

This report examines these risks, summarised in Table 1b, which highlights areas of high likelihood and impact across the Li-ion battery value chain, for both LFP and NCM technologies.

Table 1b: Summary of environmental and social risks at each stage of the battery value chain.[6]

		Raw material extraction				Material processing	Cell and pack manufacturing	Battery installation	End-of-life management
		Mining of key minerals such as lithium, nickel, cobalt and graphite.				Raw materials are purified using thermal and chemical treatment.	Cathode, anode, separator and electrolyte are assembled into a cell.	Battery packs are installed into a product such as an EV.	At the end of their lifecycle, batteries are either re-used, recycled or disposed of
		Lithium	Nickel	Cobalt	Graphite				
Environmental risks									
Air	GHG emissions	H	H	H	H	H	H	M	H
	Air pollution	M	M	H	H	H	M	L	H
Water	Water pollution	H	H	H	H	H	M	L	H
	Water withdrawal	H	H	H	M	M	L	L	M
Soil	Land pollution	M	H	H	H	H	L	L	H
	Land degradation	H	H	H	H	M	L	N	H
Biodiversity	Reducing biodiversity	H	H	H	H	M	L	N	M
	Deforestation	M	H	H	M	N	N	N	N
Resource depletion	Resource depletion	M	M	H	M	L	L	L	L
Hazardous substances	Radioactive	L	L	L	L	N	N	N	N
Social risks									
Fair working conditions	Child or forced labour	L	H	H	H	M	L	N	H
	Fair wages and working conditions	M	M	H	M	M	M	L	H
	Health and safety of workers	M	M	H	H	H	H	L	H
Community	Protecting the rights of local communities	H	H	H	H	L	L	L	L

Highest risk

Key: H High, M Medium, L Low, N Limited Evidence in literature

Sources: IEA, Child Labour Platform, ILO, Harvard International Review, S&P Global Market Intelligence, Benchmark Minerals, Nature Reviews Earth & Environment, Reuters, USGS, Centre on Global Energy Policy, Global Battery Alliance, National Minerals Information Center, Global Witness, Financial Times, Bloomberg, Rainforest Rescue, RAID, Amnesty International, Faraday Institution, Geneva Center for Business and Human Rights, Human Rights Watch, WEF, IIED, and other; PwC Strategy& Analysis

Governments are increasingly aware of these risks, with the EU leading regulatory response. The EU has introduced a range of measures to drive responsible sourcing, such as the EU Battery Regulation adopted in 2023. The policy mandates performance, durability, and recycling standards, requiring Original Equipment Manufacturers (OEMs) to comply with due diligence obligations in line with broader EU sustainability and environmental standards.[6] It also laid the foundation for the EU Battery Passport, a digital record that will have comprehensive battery performance, management and sustainability information.[2]

However, implementing these regulations presents challenges. For example, the Battery Passport requires extensive data collection and verification, raising concerns about standardisation, compliance burdens, and data privacy. Additionally, aligning regulatory approaches across jurisdictions remains complex, requiring greater international cooperation to ensure consistency and effectiveness.

Other countries such as the US, Japan and Australia are also exploring similar regulatory measures, driven by sustainability, geopolitical and economic factors. As the current value chain is highly concentrated in China - the EU, US, and some Asia Pacific countries, including Japan and Australia, are drafting policies to bolster domestic production.[7] These measures aim to build supply chain resilience and deliver local economic benefits through financial incentives for domestic production, responsible material sourcing, innovation, as well as tax credits to stimulate consumer demand.

Technological advancements are unlocking commercial opportunities while enhancing sustainability. Companies are adopting electric-powered equipment and renewable energy to cut GHG emissions and air pollution. They are also exploring alternative extraction methods that could improve extraction recovery rates, reduce energy use and limit land degradation. Localising these processing and manufacturing facilities closer to customers further shortens supply chains, reducing distribution-related emissions. At the same time, research is advancing alternative battery chemistries, such as Lithium-sulphur, solid-state, and Sodium-ion batteries. While at an earlier commercial stage than Lithium-ion, these innovations promise longer lifespans, higher energy densities, and reduced reliance on scarce materials.

The battery value chain is increasingly adopting circular principles to reduce the raw materials required, minimise waste, and extend product life. Circularity alleviates negative impacts by extending the lifecycle of products, reduces reliance on countries with weak governance and regulation, and has the potential to be more cost-effective than using new resources if economies of scale are achieved. Near-shoring the end-of-life stages can enhance these benefits by reducing transportation emissions, lowering costs, and improving recycling efficiency, thereby strengthening local economies and supply chain resilience.

As EVs become more common, the volume of batteries reaching the end of their life will rise. Landfill disposal is unviable due to safety, environmental, and regulatory concerns in countries with strong regulation – batteries must instead be collected and transported to facilities equipped for hazardous material disposal.[ii] Governments are also implementing measures to promote circularity. The EU has set ambitious targets for minimum recycled content and material recovery by 2030,[iii] alongside extended producer responsibility requirements.[6] These efforts are driving the global battery recycling market, expected to grow fivefold by 2030, with 70% of capacity in China and 10% each in the US and EU.[8]

Beyond recycling, repurposing batteries for second-life applications is gaining traction. For instance, EV batteries can be used in Battery Energy Storage Systems (BESS), where a lower energy density is acceptable. Widespread adoption of second-life applications is expected in the 2030s as more batteries reach the end of their lifecycle. However, improvements are needed to ensure they meet standards for usability and safety. Additionally, battery packs that are designed with circularity considerations from the outset are expected to further enable a circular economy.[2]

[ii] Applicable to countries with robust environmental regulation and governance, countries with weaker environmental regulations may still rely on landfill disposal.

[iii] New batteries introduced to the market will be required to meet minimum recycled content standards. From 2030, they must contain at least 12% recycled cobalt, 4% lithium, 4% nickel, and 85% lead. By 2035, these thresholds will rise to 20% for cobalt, 10% for lithium, 12% for nickel, and remain at 85% for lead.

In a complex value chain, investors can act by:

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Advocate for greater corporate disclosure of ESG considerations, including ethical and environmental considerations.

- **Enhance due diligence practices**
  - Source location of raw materials
  - Comprehensive Life Cycle Assessments (LCAs)
  - Standardised tools and frameworks
  - Third party audits
- **Encourage effective reporting**
  - Transparent processes and platforms
  - Reporting initiatives, e.g. EU Battery Passport

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Encourage corporate action to address ESG risks at every stage of the value chain.

- **Raw material extraction**
  - Strengthen oversight of mining practices for ethical sourcing.
- **Supply chain**
  - Improve transparency and traceability across supply chain.
- **Manufacturing**
  - Implement stricter ESG standards to reduce emissions and waste.
- **End-of-life**
  - Prioritise recycling and reuse to support circular economy principles.

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Foster partnerships with companies, investors, government, and NGOs to drive innovation, sustainability, and knowledge-sharing.

- **Company partnerships**
  - Partnership between vehicle manufacturer and tech firm to expand closed-loop battery recycling programme.
- **Public-private collaboration**
  - Reporting standards and mechanisms for implementing EU Battery Passport.
- **Multi-stakeholder initiatives**
  - Global Battery Alliance launched by WEF that brings together businesses, governments, NGOs and academia to promote sustainable production.

4 | Endnotes

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