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Europe's Hidden Mine

Turning End-of-Life EV Batteries Into a Competitive Refining Industry

Deloitte Point of View

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Executive summary

- Europe is **structurally short on primary critical raw materials** (Ni, Co, Li), yet sits on **a growing urban mine of electric vehicle (EV) batteries** and production scrap circulating on its roads and in its gigafactories.

- Refining these materials into recycled metals (which will ultimately feed into new EV batteries) is a critical step within the recycling chain but it is **still immature in Europe.** Most European black mass (feedstock for the refining process) is **exported and ultimately refined in Asia, particularly China.**

- This reflects a **structural competitiveness gap:** European projects face capital expenditures and operational expenses roughly **2.5–3 times higher than Chinese plants,** leading to lower payability for suppliers and structurally weaker margins.

- The EU Battery Regulation will create **mandatory demand for recycled content from 2031,** and upcoming export restrictions on black mass to non-OECD countries will curb the most direct leakage routes. Yet the regulation **still does not require this content to be refined in Europe** – leaving significant **loopholes** that allow European feedstock to flow offshore.

- Left unaddressed, the competitiveness gap will lock Europe into **a costly dependency – subsidizing Asian refining capacity to meet its own regulatory targets. Two strategic levers** can break this dynamic. First, **protection:** securing feedstock within European borders and guaranteeing offtake for domestic refiners. Second, **incentivization:** deploying subsidies to close the cost gap – including to extra-European players willing to enter joint ventures and transfer refining know-how. The **winning formula will likely combine both,** calibrating trade protection and financial support to attract investment while building genuine European sovereignty.

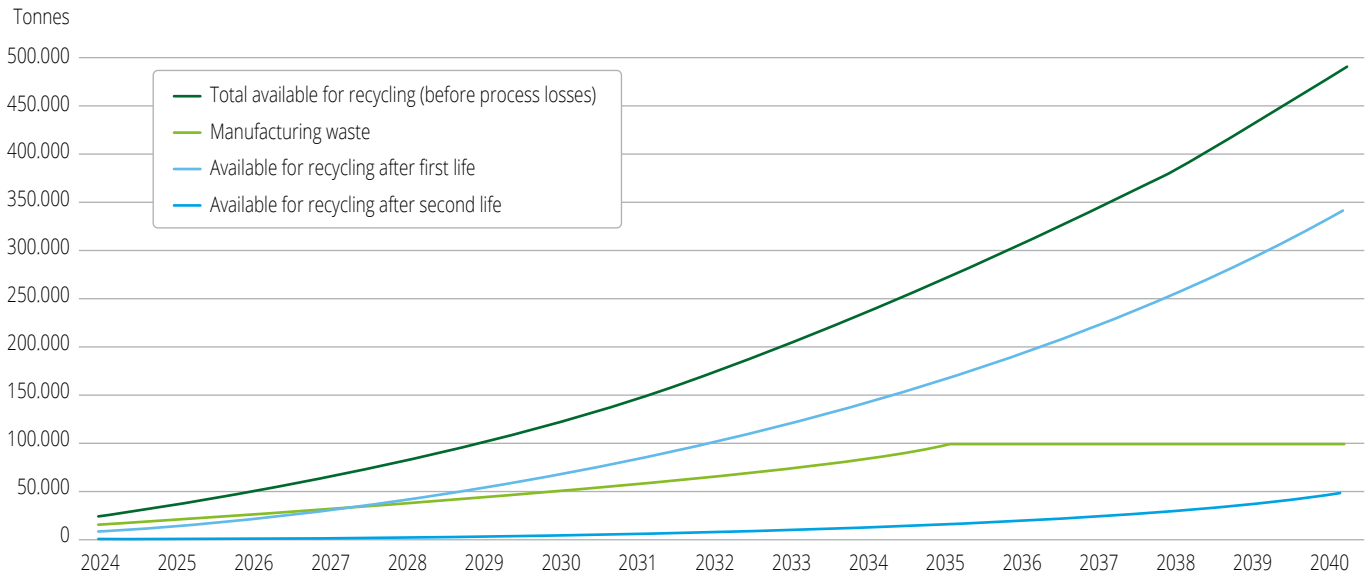
Europe's hidden mine – and the refining bottleneck

The EU Battery Regulation (2023/1542) has set ambitious battery recycling targets, demanding that new EV batteries include a minimum share of recycled metals by 2031 (16% for Cobalt, 6% Nickel, and 6% Lithium) and by 2036 (26% for Cobalt, 15% for Nickel and 12% for Lithium).

In parallel, EU targets to reduce automotive carbon emissions by 90% by 2035 (EU Automotive Package) has boosted EV sales, making its EV fleet a rapidly growing secondary resource for battery metals, on top of battery production scraps.

By 2028, the main feedstock for battery recycling will evolve from manufacturing scrap to end-of-first-life batteries, as highlighted by Deloitte in its position paper co-authored with the Global Battery Alliance "Navigating the Unknown - drivers and projections for EV battery recycling". Indeed, EoL battery volumes are expected to grow sharply over the next decade, making black mass a strategic feedstock in Europe.

Projected end-of-life Li-ion EV battery cathode materials available for recycling in the EU
(in tons of end-of-life Li-ion EV battery cathode materials in the EU, 2024-2040) [link]



Source: https://www.deloitte.com/content/dam/assets-zone2/be/en/docs/industries/consumer/2025/be-navigating-the-unknowns-drivers-and-projections-for-ev-battery-recycling.pdf

The **total weight of EV battery cathodes available for recycling will grow by a factor of 20** from 2024 to 2040, reaching 500.000 tonnes.

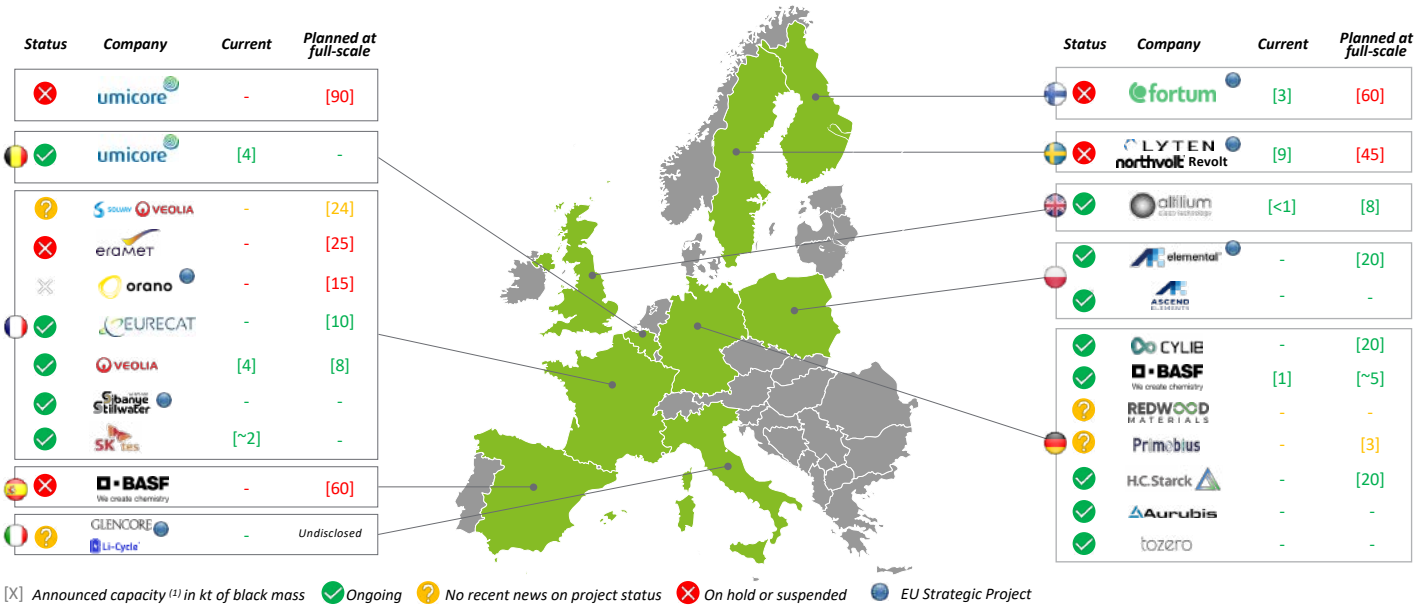
By looking at the underlying three key streams (waste, end-of-first-life, and end-of-second-life), we find:

- **Manufacturing waste currently is the main feedstock** for EV battery recycling.
- **After 2028 end of 'first life' batteries will become the largest source.** [Note: For regions like China, which produces and exports many EV batteries, the tipping point may come later]
- **Starting in 2035, second-life batteries will begin to significantly contribute to the recycling feedstock**.

With recycled content mandates approaching and domestic feedstock volumes rising fast, Europe's battery recycling value chain is rapidly taking shape. EoL battery discharging, dismantling, and shredding capabilities have developed, and several players are already capable of producing black mass at industrial scale. However, the value-added step of black mass refining remains underdeveloped: most European projects are at pilot or early industrial stage and remain far from the scale of Asian plants. As a result, European black mass is predominantly exported, often via an OECD country such as South Korea before being rerouted to China, where it is refined into high-value recycled salts.

This configuration is strategically problematic for Europe, which loses both the economic value from refining and the strategic control over critical materials. EU Original Equipment Manufacturer (OEMs) and cell makers increasingly rely on Asian recyclers, who can already integrate recycled content at or above EU 2031 targets, often at lower cost.

Overview of refining projects in EU (publicly announced refining capacity in kt of black mass, at current and at full-scale)



Notes: (1) Based on publicly available announcements; Sources: Deloitte research & analysis



State of play: refining capacity and economics in Europe

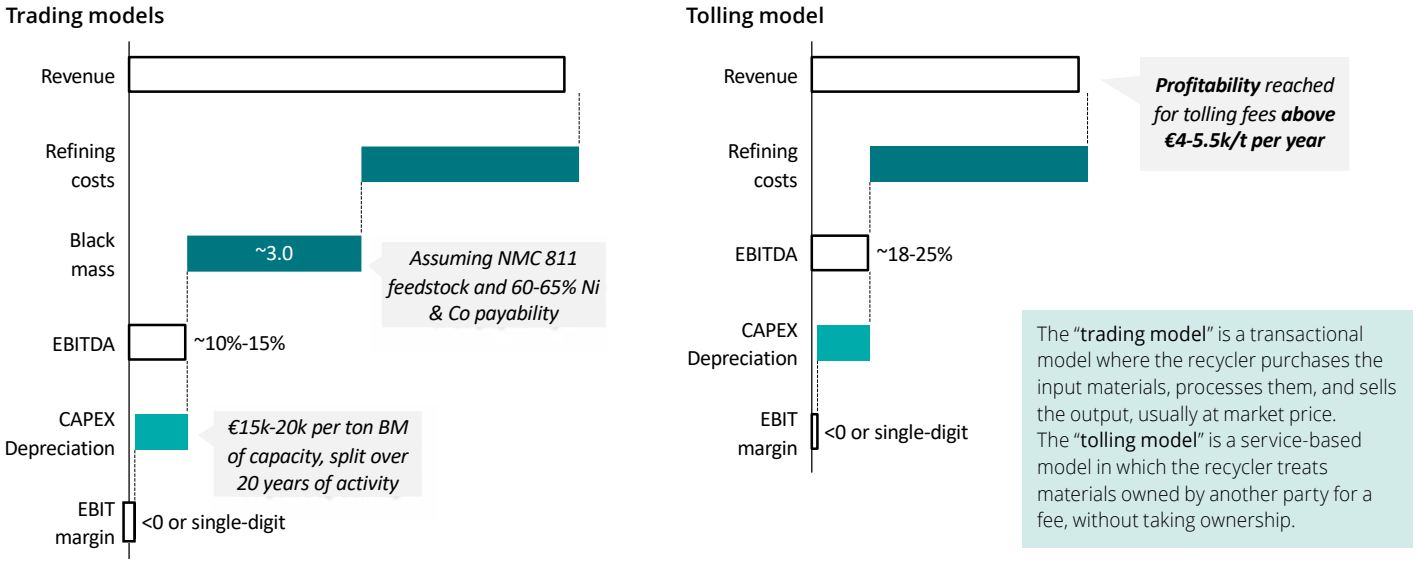
Europe's ambitions on battery circularity are colliding with the hard reality of an immature and economically fragile refining ecosystem. While policy momentum is strong and the volume of black mass is set to rise, the current European refining landscape remains fragmented, sub-scale and under pressure from structurally higher costs than its Asian competitors.

Most European refining projects are still far from industrial maturity. Players such as Umicore, BASF, Fortum, Veolia/ Solvay and Primobius largely operate at pilot or early industrial scale, with announced capacities often limited to single-digit or low double-digit kilotons of black mass per year. Several flagship initiatives have been slowed, downsized or postponed altogether, reflecting a combination of capital constraints, slower-than-expected EV adoption, and the difficulty of securing robust, local end-to-end value chains. This is further compounded by the absence of a large, local pCAM/CAM[1] manufacturing base in Europe, which restricts downstream outlets for refined battery-grade salts and limits the incentive to invest at scale.

The economics of European refining are accordingly under significant pressure. Typical plants require around €15,000 to €20,000 of capital expenditure per ton of annual black mass capacity, with approximately 65–70% of this tied up in equipment and construction. On the operating side, refining costs (excluding the purchase of black mass itself) generally range between €3,000 and €4,500 per ton, reflecting high input costs for reagents, energy and labor. Under current market conditions—taking NMC811 feedstock and payability in the 60–65% range as a reference—gross margins tend to sit in the 10–15% band. Once depreciation is accounted for, this often translates into EBIT margins at or below zero. Profitability remains highly exposed to metal price cycles, particularly for nickel and lithium: the 2022 price spike briefly transformed recycling into a very attractive business; the subsequent "lithium winter" pushed many projects back towards breakeven or negative economics.

In parallel, business models are evolving in ways that can either amplify or mitigate this volatility. Historically, many EU recyclers operated on a "recycling fee" model, being paid to take in batteries and capturing upside through the sale of recovered metals. This model is now giving way to a trading approach, where recyclers must pay for feedstock, typically black mass, thereby increasing their exposure to metal price swings and competitive bidding for volumes. In response, tolling models are gaining traction, particularly in long-term partnerships with OEMs and cell manufacturers. Under tolling arrangements, the recycler processes black mass for a fee while the client retains ownership of the material and the associated price risk, offering a more stable earnings profile.

High-level P&L[1] of a European refining plant
(in k€ per ton of black mass per year, 15-30 kt capacity plant, under a trading and tolling models)



Notes: 1. Under current conditions, European-recycled materials usually reach technical grade, with most upcoming projects aiming for battery grade outputs. Sources: Expert interviews, Deloitte research & analysis

1 Cathode Active Material (CAM) is the key powder inside a battery that determines how much energy it can store and how long it lasts. Producing it requires first to make a precursor CAM (pCAM), which is a mixed metal compound (using recycled salts). pCAM & CAM production is a complex and essential step in the battery value chain, yet with no major production in Europe

The structural cost-gap with Chinese refiners

Europe's ambition to lead on battery circularity is constrained by a structural competitiveness gap vis-à-vis Asia, and particularly China. Across capital costs, operating costs, margins and industry structure, European refiners are less competitive.

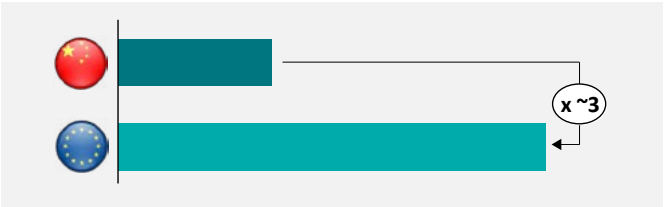
The cost gap is significant. For a 30 kt plant, total CAPEX in Europe is close to 3 times higher for equivalent capacity. Annual operating expenditure (excluding black mass feedstock) shows a similar pattern: approximately 2.5 times higher in Europe compared to China. Part of the CAPEX differential reflects Europe's stricter environmental, health and safety (EHS) standards, which can represent up to half of total project investment. On the operating side, European refiners face structurally higher labor costs, often three to six times those in China or India, and energy prices that can be up to three times higher in certain geographies. Less mature operations, smaller average plant size and higher relative overheads further erode cost competitiveness.

These cost headwinds translate directly into weaker payability and thinner margins. Today, European refiners can typically offer about 60–65% payability for nickel and cobalt contained in black mass, an improvement from around 50% in 2020 and temporarily peaking at roughly 70% in 2022–23, but still below Asian benchmarks. By contrast, Asian refiners often offer 75% or more, and in some cases provide at least modest payability for lithium. European contracts generally do not include payability for lithium, though it is sometimes considered indirectly in the nickel and cobalt payability. Along with a reduced cost structure, overcapacity of Chinese refiners is what pushes payability rates up, as such players look to purchase available black mass to fill their plant capacity. The result is a structural profitability gap: European players tend to achieve only 10–20% gross margins and low single-digit or even negative EBIT, while Asian competitors can reach up to 40% gross margins and EBIT levels in the 15–20% range.

Capital expenditures (CAPEX) and operating expenses (OPEX) gap between Europe and China for a standard 30 kt capacity black mass refining plant

CAPEX

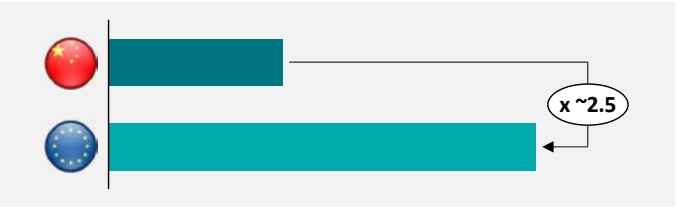
Total CAPEX for a refining plant of 30 kt



- **Average CAPEX per kt of black mass**, calculated over multiple comparable refining European projects, **multiplied by 30 kt**
- European CAPEX is **~3 times** superior to China: 2.5x due to cost differences, 0.5x due to subsidies

OPEX (excluding black mass)

Total annual OPEX (excluding black mass) for a refining plant of 30 kt



- **Black mass not considered**
- **OPEX split:** Reagents (22-38%), Energy (20-35%), Labor (9-21%), maintenance (5-18%), waste disposal (~5%), other expenses (~11%)
- **OPEX per ton of black mass** processed for a European plant: **€3,000 - 4,500**

- **European CAPEX and OPEX ~3 times less competitive than China**
- The competitivity gap can be explained by several factors, i.e. higher CAPEX in Europe due to **stricter environmental regulation, smaller plant scale, less mature operations and lower government support** (e.g., subsidies) combined with higher OPEX driven by **higher labor cost and lower energy cost**
- China's underutilized refining capacity is likely to **intensify price competition** and **further divert black mass away from Europe**

Regulation, intended to support circularity and sovereignty, is not yet closing this competitiveness gap, and in some respects reinforces it. Since June 2025, black mass is qualified as "hazardous waste" under the EU Waste Shipment Regulation, which will prevent it from being exported from the EU to non-OECD countries by December 2026. However, significant loopholes remain: black mass can still be processed into intermediate products in an OECD country such as South Korea and subsequently shipped to China for final refining. Moreover, the EU Battery Regulation does not require that the recycled content used to meet 2031 and 2036 targets be refined in Europe. OEMs and cell-makers are therefore free to source lower-cost recycled metals from Asian refiners to satisfy European regulatory obligations. Meanwhile, Chinese refiners benefit from decades of state-directed investment, subsidies and deliberate vertical integration, which have enabled large-scale plants, dense industrial clusters and steeper learning curves.

Underlying these dynamics is a profound difference in industrial structure. Leading Chinese players such as CATL/Brunp, Huayou, CNGR and GEM operate highly integrated "closed-loop" ecosystems. Their activities span scrap collection, dismantling, shredding, refining and production of pCAM/CAM, often co-located with gigafactories to secure feedstock and offtake. Europe, by contrast, is still characterized by fragmentation: multiple independent actors operate each step (dismantling, shredding, refining, cathode production) generally at smaller scale and with weaker long-term offtake visibility. This lack of integration limits the ability to optimize logistics, share infrastructure, derisk investments and capture synergies across the value chain. As long as these structural disadvantages persist, Europe will struggle to match Asia's cost, margin and investment dynamics in battery material refining.



What would it take to make Europe competitive?

Closing Europe's competitiveness gap in battery materials refining will require more than incremental improvements. It demands a deliberate shift from a "permissive" approach to circularity, where recycled content can be sourced wherever it is cheapest, to a strategic industrial policy that anchors feedstock, demand, capital and know-how within Europe. The question is less whether Europe can recycle its own EV batteries and production scrap. It is more about how it can build a profitable, globally competitive refining ecosystem around them.

A first pillar is regulatory. Today, export restrictions on black mass to non-OECD countries are a step in the right direction, but loopholes allow material to end up in China for final refining. Closing these back doors, by tightening rules on intermediates derived from black mass and enforcing robust traceability, would help ensure that EU-generated black mass is either refined in Europe or clearly accounted for separately. At the same time, regulation needs to create explicit demand for metals refined on European soil. Regional origin mandates, whereby a defined share of the recycled content required in EV batteries must come from EU-refined materials, would send a strong signal to the market. Clarifying how black mass treated outside the EU counts towards regulatory targets is equally critical to avoid undermining domestic projects. Finally, closing the CAPEX gap will require public support at scale, using grants, guarantees and concessional finance to lower the cost of capital, can help de-risk the substantial upfront investments in a way that mirrors China's long-term support to its recycling and refining champions.

Beyond regulation, Europe has to rethink the underlying economic model. The current paradigm, where refiners compete on feedstock as commodity traders, leaves them overly exposed to metal price volatility and erodes margins. Shifting towards "recycling as a service" can stabilize returns and attract institutional capital. In such models, OEMs and cell makers retain ownership of the material and pay refiners a processing fee, while refiners commit to specific recovery rates and quality levels. Economic value would be shared transparently through payability formulas and service fees. In this architecture, OEMs are natural orchestrators of the value chain. They can "close the loop" by directing their cell suppliers to procure from designated refiners via directed-buy contracts. A industry-wide accounting systems will also be required to trace metals from battery to black mass, to salts, to cathode active materials (CAM) and back to battery.

Technology and partnerships form the third pillar of competitiveness. The fastest way for Europe to narrow the process gap with Asia is to import and adapt proven technologies and operational know-how. Joint ventures, licensing arrangements and co-development partnerships can accelerate the deployment of mature refining processes in Europe; this is already happening,



with examples of Asian players licensing their technologies to European refiners. At the same time, European players have to further innovate on process efficiency. Simplified flowsheets, such as hydro-to-pCAM routes, can reduce the number of unit operations, cut CAPEX and lower operating costs. Some European projects pursuing innovative hydro-to-CAM pathways already claim cost parity with Asian refiners.

Competitiveness will also hinge on how plants are designed and where they are located. Co-locating refining facilities within existing industrial platforms, such as chemical clusters, ports or gigafactory campuses, allows projects to tap into pre-existing utilities, logistics and skilled labor pools, improving economics and time to market. Plant design will need to anticipate the evolving chemistry mix of the European fleet, balancing NMC and LFP streams and adapting processes accordingly. For lower-value LFP batteries, optimizing process economics and exploring alternative value propositions, such as iron phosphate reuse or integration into other industrial value chains, will be essential to maintain viability. Finally, Europe must invest systematically in skills and operational excellence. Training programs, technical exchanges and the adoption of best practices from more mature plants in China and the US can shorten Europe's learning curve and reduce the competitivity gap.

Combining these levers of strategic regulation, new economic models, targeted technology partnerships and disciplined industrial execution can reposition European refining as a competitive, resilient pillar of the continent's energy transition and industrial sovereignty.

A strategic choice for Europe's battery value chain

Europe's battery strategy is approaching an inflection point. The core constraint is no longer the availability of critical metals in the European "urban mine" of end-of-life batteries and production scrap, but the continent's ability to capture value domestically through competitive refining. Put simply, Europe has the metals; what it lacks is sufficient, efficient capacity to turn black mass into high-value battery-grade materials on its own soil.

If regulation, economics and technology remain unchanged, Europe risks locking in a structurally unfavorable position: a net exporter of strategic waste and an importer of high-value recycled metals from Asia. In that scenario, European black mass flows abroad to be upgraded into battery-grade salts, only to re-enter the market embedded in cells and packs, along with the margins, jobs and strategic control that have been captured elsewhere.

A different outcome is possible. With targeted, coordinated interventions, Europe can build an investable, profitable and strategically autonomous refining industry.

Closing export loopholes and introducing clear mandates for EU-refined recycled content would anchor both feedstock and demand. Public support for capital expenditures, combined with more stable tolling-based business models and multi-party ecosystems, would de-risk projects and attract private capital. Partnerships that improve Asian technologies , and relentless innovation would help close the technology and cost gap quickly.

For policymakers and industry leaders, this is no longer a theoretical debate but a near-term investment decision. With more than 150 000 tons of EV battery cathodes materials available for recycling in Europe by 2033 (as highlighted by Deloitte in its position paper co-authored with the Global Battery Alliance), the refining plants must be financed, permitted and built now. Whether Europe becomes a price-taker in global recycling or a sovereign hub for high-value battery materials will be determined by choices made in the next few years.



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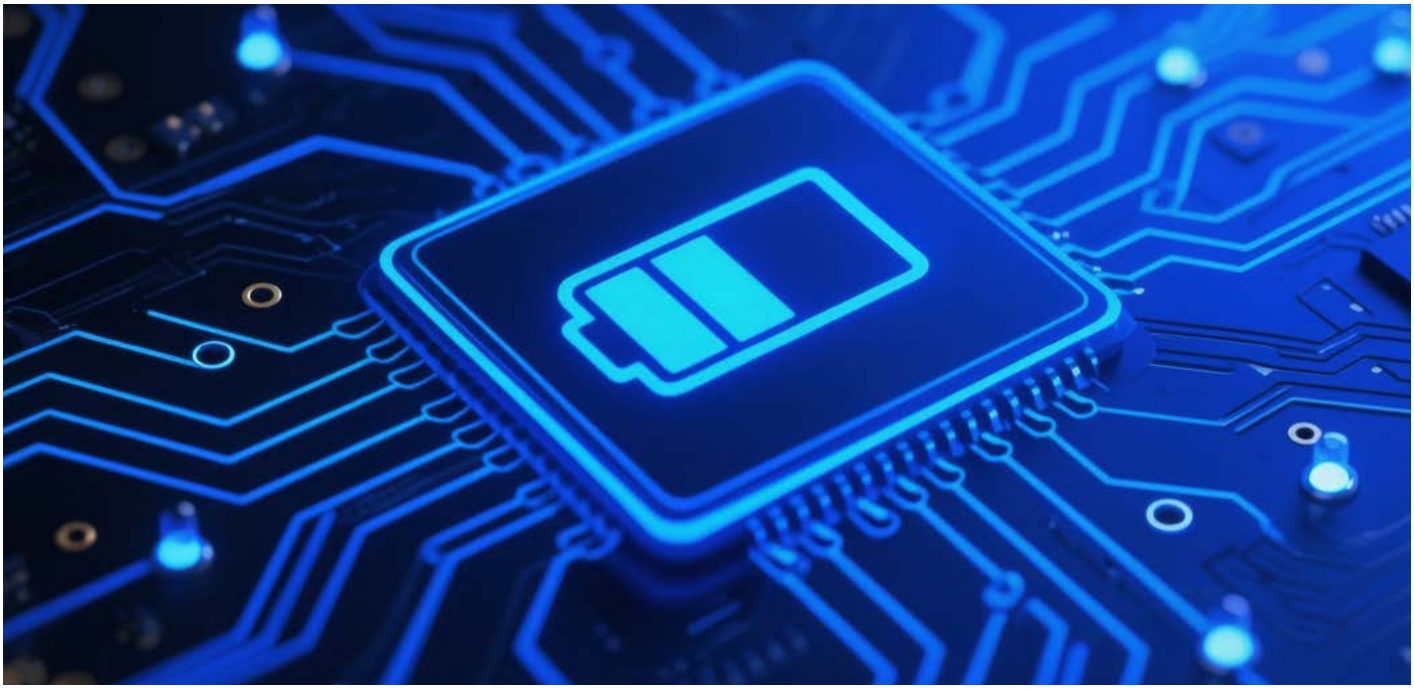
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