Europe’s Most Valuable Mine Is a Scrapheap

230–420 kt
EU recycling feedstock in 2030

August 2031
the law starts buying recycled metal

3 to 5 per cent
of the lithium price a black-mass seller keeps

Regulation and returning batteries are turning dead cells into industrial raw material. The race is for who captures it.

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Energy and Circular Economy

Europe's Most Valuable Mine Is a Scrapheap

Regulation, returning batteries and factory scrap are turning dead batteries into industrial raw material. Who captures the value, and with whose money, is an open race.

230-420 kt
EU recycling feedstock in 2030, rising to 1,500-2,100 kt by 2040

Aug 2031
the law starts buying: 16% cobalt, 6% lithium, 6% nickel

3-5%
the share of the lithium price a black-mass seller keeps

CAPABILITY DEMONSTRATED
Bankability and impact-metrics analysis

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A showcase of the Quorum evidence pipeline. This report summarises a small part of a much larger body of research; the scale of that work, and how to commission it, are set out on the closing page.

Prepared by Serinyx GmbH. Every factual statement carries a superscript reference to a verified source list. AI disclosure: researched, drafted and checked by Serinyx's Quorum evidence pipeline under named human sign-off; it should empower human judgement, not replace it.

CONTENTS

Sections

Also in this report

Every section header states the number of separately sourced claims that section rests on. Superscript numerals throughout resolve to the reference list; each figure and table carries the claim ids behind every value it prints.

EXECUTIVE SUMMARY

Europe is about to inherit a mine it never dug. The yearly flow of battery waste and factory scrap available for recycling was 96,000 tonnes in 2024[37]. Forecasts put it at 230-420 kt (thousand tonnes) in 2030 and 1,500-2,100 kt by 2040, a five- to sixfold rise inside a decade, on dates set by cars already sold[1-4]. EU law turns that flow into demand. Recyclers must recover 50% of the lithium in the batteries they process by end-2027, and from August 2031 every new EV, industrial and starter battery sold in the EU must contain minimum shares of recycled cobalt, lithium and nickel[5]. One thing the law, as harvested, does not say: that the recycled material must have been recycled in Europe[5]. That silence is the open flank in the whole story, and this report keeps it in view throughout[5,7].

The value does not sit in collecting or shredding, which Europe already does. It sits in refining black mass, the metal-rich powder from shredded packs, back into battery-grade chemicals, which Europe mostly does not: China held 89% of refining capacity in 2025, and sellers of the powder received 3-5% of the lithium price in mid-2024 assessments[6,7]. Europe's counter-buildout is real and this report names it plant by plant, from Europe's first industrial lithium-recovery line to its first industrial line for LFP cells (lithium iron phosphate, the cheaper chemistry with no nickel or cobalt to reclaim)[38–40]. But the operating plants are counted in tens of thousands of tonnes, and the 2040 wall in millions[1–3,41–43].

Against the buildout stands a casualty list: Northvolt and Li-Cycle bankrupt within three months of each other, lithium down roughly three-quarters from its 2023 average, many plants below 10% utilisation, and installed capacity already almost three times the waste arising[11,12,14,20–22]. So the deciding variable is money. The corpus's project economics reach an 8-10% yearly return in the base case, viable with concessional finance but not compelling for private capital alone, and one German region alone shows a €510-810 million financing gap to 2030[19,25]. The quotas will feed whoever is still standing in August 2031; still standing is first a financing question[5,19].

01 Three key numbers

RESTS ON 5 SEPARATELY SOURCED CLAIMS

Europe is about to inherit a mine it never dug.

From 230-420 kt to 1,500-2,100 kt. Europe's yearly flow of battery waste and factory scrap for recycling, in kt (thousand tonnes), 2030 to 2040: a five- to sixfold rise inside a decade, on dates set by cars already sold[1–4].

16% cobalt, 6% lithium, 6% nickel. The recycled content every new EV, industrial and starter battery sold in the EU must contain from August 2031, rising to 26%, 12% and 15% in 2036: demand written into law, whatever metals cost, while the law holds[5].

3-5%. The share of the lithium price sellers of black mass (the metal-rich powder from shredded batteries) received in mid-2024 assessments[6]. The discount goes to whoever refines; 89% of that capacity sits in China[6,7].

02 The wall is already on the road

RESTS ON 18 SEPARATELY SOURCED CLAIMS

The raw material for Europe's next buildout is already sold and parked on driveways. Some 17 million electric cars were sold worldwide in 2024, roughly 21% of new cars, and the forecast passes 40 million a year by 2030; every sale schedules a retirement[4,8]. EV batteries carry 8-10 year warranties and last 15-20 years[4]. So the first wave begins in 2028-2030, as the earliest 2018-2020 packs exit the warranty band, and peaks through 2035-2040 as the rest live out full lives[4]. Nobody has to prospect this mine; the ore is parked outside, arriving across a decade[4].

The near years are measured, not modelled. Europe generated about 96,000 tonnes of battery scrap and end-of-life batteries in 2024, and the same assessment series projects 252,000 tonnes by 2029, a 2.6-fold rise in five years[37]. Waste arising in 2025 runs near 100 kt[12]. The consensus band then climbs: 230-420 kt a year in 2030, 390-800 kt in 2035, 1,500-2,100 kt by 2040[1–3]. For scale: Germany, Europe's largest battery-recycling market, processed about 213,000 tonnes of batteries of all chemistries in 2022; the 2040 flow is seven to ten times that, every year[1–3,44,45].

Counted in packs rather than tonnes, the estimates disagree on scope but not on direction. About 8 million lithium-ion batteries reach end-of-life in Europe within five years on one count; another puts end-of-life EV batteries at 1.2 million a year; a third projects more than 6 million packs retiring annually by 2030[4,46,47]. We use them as direction, not as one series[4,46,47]. Two silent leaks qualify the wall. Cars exported second-hand before retirement leave the European ore body uncounted, a gap the corpus does not fill and How we know lists. And every pack diverted into second-life storage (used EV packs reused for stationary power storage) arrives at the recyclers a battery-lifetime later[24,47,48].

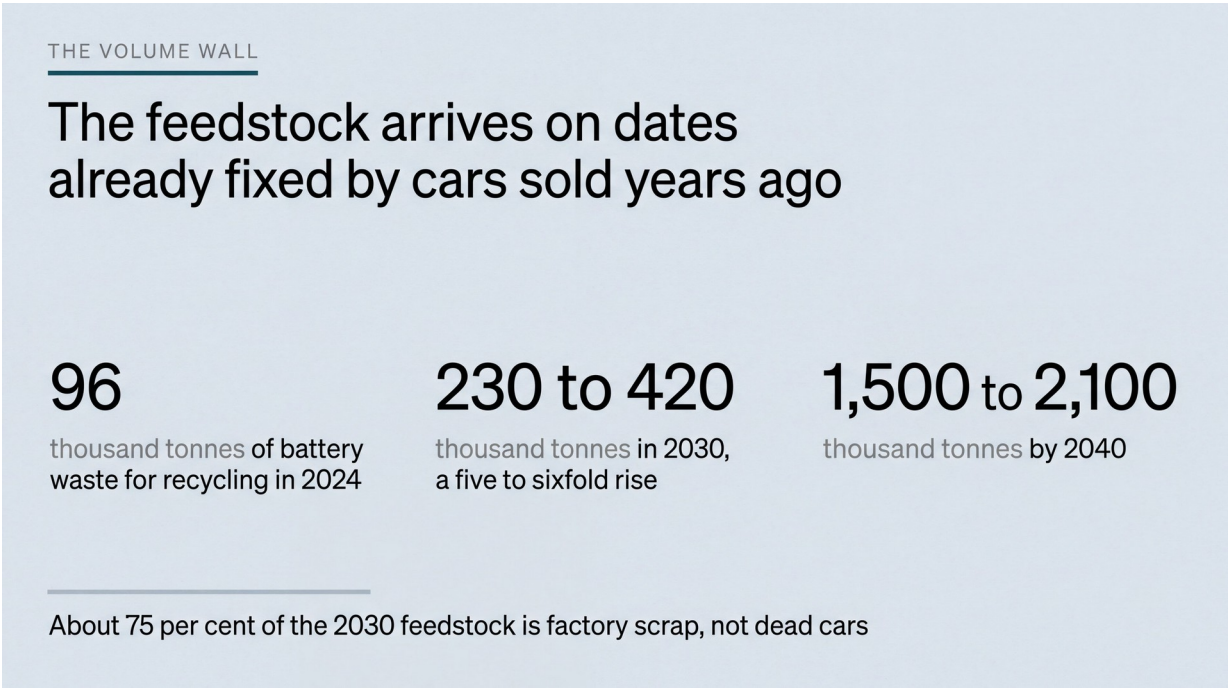
Before the cars arrive in numbers, the plants run on factory waste. About 75% of expected 2030 feedstock (the material plants run on) is production scrap from gigafactories (industrial-scale cell plants), not dead cars[2]. Scrap peaks around 2030; end-of-life batteries dominate after 2035[1–3]. One region shows the handover in miniature. In a German industrial region, the corpus models end-of-life EV batteries growing from 5,000-8,000 tonnes a year today to about 25,000 in 2027 and past 60,000 by 2030[49]. Manufacturing scrap there grows from 15,000-20,000 tonnes to about 50,000, with consumer electronics near 15,000 and stationary storage about 10,000 by then[49]. Scrap leads now; the dead cars take over by decade end[1–3,49]. The material already crosses borders: one long-established German recycler sources 60% of its input from the Netherlands, Belgium and Scandinavia, and only 15% from end-of-life EV batteries so far[39].

But scrap cuts both ways: it depends on the cell buildout whose flagship, Northvolt, went bankrupt in March 2025, and the research corpus behind this report has no figure for how much production ends as scrap[2,11,12]. The scrap story rests on the 75% share, not on a measured scrap rate, and we say so again in How we know[2].

Shredding the flow yields black mass: 40-50% of a pack's weight, carrying its lithium, nickel, cobalt and graphite[10]. The prize on top is a market. One vendor forecast puts global lithium-ion battery recycling at €11.9 billion in 2025, reaching €105.5 billion

by 2035; the corpus's all-chemistry consensus is wider and slower, €11.0-24.7 billion in 2024 growing to €17.8-70.9 billion by the early 2030s[29,50]. Vendor forecasts earn a health warning: the corpus caught its own earlier estimate understating the 2025 market by about 80%[29]. Europe held 37% of the global lithium-ion recycling market in 2025, and Germany 47.3% of Europe's, a national market projected to grow from $552.6 million in 2024 to $4.28 billion by 2035[29,44,45,50].

EXHIBIT 1



Serinyx Quorum evidence ledger; every plotted value traces to a claim id.

03 The market is manufactured by law

RESTS ON 19 SEPARATELY SOURCED CLAIMS

The discount goes to whoever refines, and most of that capacity is not in Europe.

This market answers to price, and to a regulator with dates in the diary[3]. EU Regulation 2023/1542 makes recyclers recover 50% of the lithium in the batteries they process by end-2027 and 80% by end-2031, alongside 90% rising to 95% for cobalt, nickel and copper[5]. From August 2031, new EV, industrial and starter batteries sold in the EU must contain minimum recycled content: 16% cobalt, 6% lithium, 6% nickel, rising to 26%, 12% and 15% in 2036[5]. In plain words: a legal minimum share of each metal must come from recycled sources, whatever metals cost, while the law holds[5].

The paperwork arrives years before the quotas bite. The method for calculating recycled content is due by delegated act (the Commission's follow-on rules) from 18 August 2026, and every battery maker must declare recycled content from 18 August 2028, three years before the binding minimums[5]. From 18 February 2027, every EV and industrial battery above 2 kWh sold in the EU needs a Digital Battery Passport: a travelling digital record of its materials, recycled-content shares and state of health[5]. It is how a battery proves where its lithium has been; it makes the quota checkable[5].

Alongside the recovery targets sit efficiency and collection duties. Whole-process recycling efficiency for lithium-based batteries must reach 65% by weight, rising to 70% by end-2030; lead-acid batteries carry 75% rising to 80%, nickel-cadmium 80%, others 50%[5]. One date here we cannot print cleanly: the corpus's compliance table puts the 65% step at 2027, while the regulation's annex, as adjudicated elsewhere in the same corpus, sets it at end-2025[5]. We carry the conflict rather than pick a side, and it goes to verification before publication[5]. Collection is layered by battery type: portable batteries must hit 63%

collection by end-2027 and 73% by end-2030 (Germany already mandates 50%), light-transport batteries 51% by end-2028 and 61% by end-2031, and EV and industrial batteries carry a 100% take-back obligation outright[5,32].

Carbon rules run on their own clock. Carbon-footprint declarations became mandatory for EV batteries in February 2025 and extend to industrial batteries in February 2026; performance-class labels follow in 2026-2027; from February 2028 (EV) and February 2029 (industrial), batteries above maximum carbon thresholds are excluded from the EU market[5].

Above the battery rules sits the Critical Raw Materials Act, with four binding Union-level targets for 2030: 10% of strategic-raw-material consumption from domestic extraction, 40% domestically processed, 25% from domestic recycling, and no more than 65% of any strategic material from a single third country[30]. The EU's current recycling input rate for critical raw materials is 8.3%, a third of the way to that benchmark[30,31]. Even at scale, recycling complements mining rather than replacing it this decade. Recycled material could cover about 14% of EU lithium demand, 16% of nickel, 25% of cobalt and 17% of manganese by 2030[2]. That is enough recovered material for 1.3-2.4 million EVs in 2030, and up to 10 million by 2035[2]. The strategic motive behind the whole statute is scale: EU lithium demand is projected to grow 18-fold by 2030 and 60-fold by 2050 from a 2020 baseline, projections that predate the 2024-25 demand downgrades and are flagged accordingly[33]. An earlier corpus figure put lithium coverage at 9.9% on an unstated demand base; we replaced it with these sourced shares and log the swap in the method box[2,13].

Germany has already transposed the regime: its Battery Implementation Act took effect on 7 October 2025, municipal collection points must accept light-transport batteries from January 2026, and the €7.50 deposit on starter batteries stays. Plant permitting is the quieter constraint: statutory tracks run 3 to 7 months, realistic end-to-end timelines 12-18 months, though since February 2025 the EU's Net Zero Industry Act caps permits for strategic clean-tech plants at 12 months below 1 GW and 18 above[51,52].

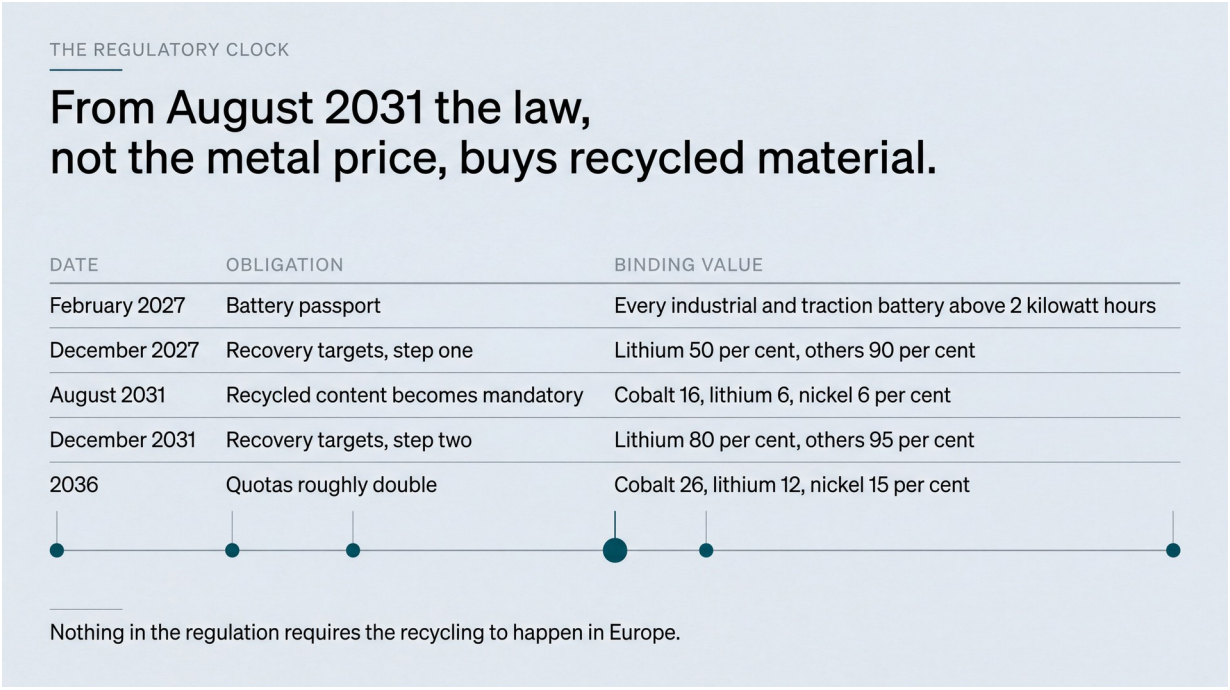
Two cautions before treating any of this as destiny. First, the floor already slipped once: the EU postponed battery supply-chain due-diligence duties by two years, to August 2027, and carbon-footprint guidance moved from February 2025 to July 2026[53]. Second, the binding steps carried here are the ones the corpus adjudicated from official texts; their calculation rules still arrive by Commission act[5]. And the narrowing that governs this whole report: nothing in the regulation as harvested requires a 2031 battery's recycled material to have been recycled in Europe[5]. The quotas guarantee demand for recycled material; whether European refiners capture it is exactly the race this report describes[5,7].

TABLE 1 **The EU regulatory timeline: the load-bearing dated steps**

Date	Step	Binding value
18 Feb 2025	Carbon-footprint declaration, EV batteries	in force[5]
Feb 2025	Net Zero Industry Act permitting caps	12 months (under 1 GW) / 18 months (1 GW or more)[52]
7 Oct 2025	German Battery Implementation Act in force	national alignment; €7.50 starter-battery deposit retained
End-2025	Recycling efficiency, lithium-based, step 1	65% by weight; corpus table says 2027, regulation end-2025, conflict carried[5]
18 Aug 2026	Recycled-content calculation methodology due	delegated act[5]
18 Feb 2027	Digital Battery Passport	every EV and industrial battery above 2 kWh[5]
Aug 2027	Supply-chain due diligence (postponed from Aug 2025)	two-year delay[53]
31 Dec 2027	Recovery targets, phase 1; portable collection	Li 50%; Co/Ni/Cu 90%; portable 63%[5,32]
18 Aug 2028	Recycled-content declaration mandatory	per battery[5]
18 Feb 2028 / 18 Feb 2029	Maximum carbon thresholds (EV / industrial)	non-compliance means market exclusion[5]
2030	Critical Raw Materials Act benchmarks	10% extraction / 40% processing / 25% recycling / max 65% one supplier[30]
31 Dec 2030	Portable collection; Li-based efficiency, step 2	73%; 70% by weight[5,32]
18 Aug 2031	Recycled-content quotas, phase 1	Co 16% / Li 6% / Ni 6%[5]
31 Dec 2031	Recovery targets, phase 2; light-transport collection	Li 80%; Co/Ni/Cu 95%; LMT 61%[5]
18 Aug 2036	Recycled-content quotas, phase 2	Co 26% / Li 12% / Ni 15%[5]
Standing	Take-back, EV and industrial batteries	100% collection obligation[5]

Sources: [5,30,32,52,53].

EXHIBIT 2



Serinyx Quorum evidence ledger; every plotted value traces to a claim id.

04 Smelt, leach or repair: the route decides who keeps the lithium

RESTS ON 19 SEPARATELY SOURCED CLAIMS

Recycling is not one industry but three competing chemistries, and the choice of route decides which metals survive[15]. Every route starts the same way: pre-treatment (discharge, dismantling and shredding) reduces packs to black mass[7]. Typical black mass runs 2-6% lithium compounds, 5-20% cobalt, 5-15% nickel, 3-10% copper and 2-10% manganese, with graphite as the remainder[10,54]. China has already standardised trading grades for the powder in a 2024 national standard; the EU has no official grade yet[10,54].

The oldest route is pyrometallurgy: smelting at 1,000-1,500°C, fully mature (technology readiness level 9, the top of the 1-to-9 scale from lab idea to routine operation), burning 2-3 MWh per tonne[15]. It keeps 85-95% of the nickel and cobalt, 60-80% of the manganese and 95-99% of the copper, but only 0-30% of the lithium; most is lost to slag, smelting's waste glass[15].

Hydrometallurgy, dissolving the powder and chemically extracting each metal at 20-100°C, uses 0.5-1.5 MWh per tonne at readiness 7-9[15]. It recovers 90-98% of the lithium, 95-99% of the cobalt and nickel and 90-95% of the manganese, which is why the EU's 2031 recovery targets are, in practice, hydrometallurgy mandates[5,15]. It already holds 65.6% of the processing market, though the source does not say whether that share is global or European; we flag the gap rather than guess[55].

Direct recycling repairs the cathode powder instead of dissolving it, relithiating spent material for reuse[15]. It recovers 95-99% of cathode material with 64% lower greenhouse-gas emissions than making it new, but sits at readiness 4-5, lab and pilot[15]. BMW and its partner Encory run such a pilot in Bavaria, on production scrap, at mid-double-digit tonnes a year[56]. Bioleaching, using microbes at ambient temperature, is the least mature route in the corpus's comparison[15].

Costs are wide bands, and ranges are all the corpus supports: smelting $26-1,851 per tonne processed, hydrometallurgy $1,555-5,662, direct recycling $4,447, bioleaching $2,000-5,000[15]. Emissions run the other way: 20-30 kg of CO2 per kg processed for smelting, 10-15 for hydrometallurgy, 2-5 for the direct route[15]. Whatever the route, a Stanford lifecycle study finds recycling cuts greenhouse-gas emissions 58-81% against virgin mining, water use 72-88% and energy use 77-89%, and recycling factory scrap carries only 19% of mining's emissions[57].

The market prices these losses without sentiment. In July 2024 assessments, sellers of nickel-based (NCM) black mass received 73-75% of the contained nickel and cobalt value, US ex-works, 68-75% delivered to Korean ports, and just 3-5% of the lithium price[6]. The discounts track the chemistry: buyers pay least for the metal most routes lose[6,15]. The difference goes to the refinery's owner, not all of it profit: it covers costs, losses and price risk[6]. Most Western black mass is exported to Asia

today: Europe lacks refining capacity, and Asian buyers pay more[6,14]. So the scarce asset is the step after shredding: refining the powder into battery-grade salts, the refined chemicals (lithium carbonate, for one) cell makers buy[15].

The claimed state of the art runs ahead of the audited one. cylib's water-based process claims above 90% recovery of lithium, graphite, nickel, cobalt and manganese at an 80% lower carbon footprint than primary extraction, validated so far at pilot scale[40]. Accurec's lithium line claims better than 99% purity[38,39]. BASF's prototype refinery demonstrates 99% nickel and 98% cobalt recovery[43]. CATL's recycling arm claims 99.6% for nickel, cobalt and manganese and 93.8% for lithium[58]. These are company figures, not audits, and we label them so[58].

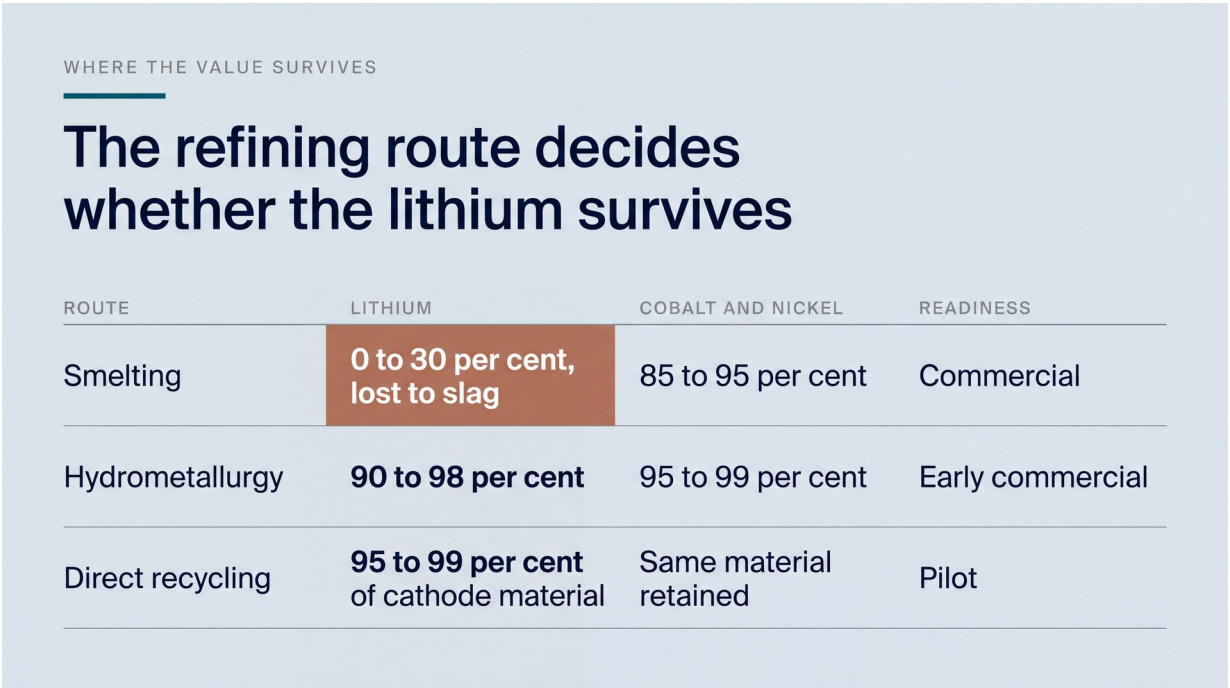
One chemistry strains every route. LFP cells (lithium iron phosphate, the cheaper chemistry with no nickel or cobalt to reclaim) carry 60-70% less recycling value per kWh than nickel-based cells, and their iron and phosphate are often not worth recovering at all[59]. cylib's Dormagen line is Europe's first industrial attempt to make that chemistry pay[40]. The bear case returns to what happens if it cannot[28].

TABLE 2 **Technology routes compared: what each one recovers, burns and costs**

Parameter	Pyrometallurgy (smelting)	Hydrometallurgy (leaching)	Direct recycling	Bioleaching
Technology readiness (1-9)	9[15]	7-9[15]	4-5, lab and pilot[15]	early[15]
Operating temperature	1,000-1,500°C[15]	20-100°C[15]	low, structure-preserving[15]	ambient[15]
Energy use	2-3 MWh/t[15]	0.5-1.5 MWh/t[15]	low[15]	very low[15]
Lithium recovery	0-30%, lost to slag[15]	90-98%[15]	95-99% of cathode material[15]	not stated
Cobalt / nickel recovery	85-95%[15]	95-99%[15]	95-99%[15]	not stated
Manganese recovery	60-80%[15]	90-95%[15]	not stated	not stated
Copper recovery	95-99%[15]	95-99%[15]	not stated	not stated
Processing cost	$26-1,851/t[15]	$1,555-5,662/t[15]	$4,447/t[15]	$2,000-5,000/t[15]
Emissions intensity	20-30 kg CO2/kg[15]	10-15 kg CO2/kg[15]	2-5 kg CO2/kg[15]	2-5 kg CO2/kg[15]

Sources:[15].

EXHIBIT 3



Serinyx Quorum evidence ledger; every plotted value traces to a claim id.

05 The capacity race: real plants, small tonnages, giant rivals

RESTS ON 31 SEPARATELY SOURCED CLAIMS

Nothing in the regulation requires the recycling to happen in Europe.

Europe is building the middle of the value chain while the top stays abroad. Operational recycling capacity of roughly 200 kt a year already doubles the roughly 100 kt of waste arising in 2025, abundance that the bear case below shows is famine for the plants[12,14]. What that capacity is made of matters, so here is the fleet, plant by plant.

The most consequential openings are recent and specific. Accurec commissioned Europe's first industrial-scale lithium-recovery plant at Krefeld on 1 December 2025: 4,000 tonnes a year from all lithium-ion battery types, lifting the site to 6,000 tonnes, with 20,000 targeted by mid-2028 and 60,000 announced long-term[38,39]. The expansion still needs permits, and the corpus disagrees with itself on how far along they are; we print the conflict[38,39]. cylib broke ground at Dormagen in September 2024 and starts production in 2027: 10,000 tonnes a year of black mass initially, targeting 60,000, roughly 140,000 EV batteries a year, including Europe's first industrial-scale LFP line[40].

The established names are further along and more cautious. BASF has run 15,000 tonnes a year of black-mass capacity at Schwarzheide commercially since June 2025, inside a €460 million investment employing 180 people[43]. Umicore operates 25,000 tonnes in Belgium with recovery above 95% for cobalt, copper and nickel and above 90% for lithium; its $525 million, 150,000-tonne mega-plant is delayed past its 2026 target[2,12,41,42]. Hydrovolt's Fredrikstad plant in Norway started at 8,000 tonnes in 2022 and added an automated second line in October 2024; sole owner Hydro inherited a 300,000-tonne 2030 ambition from the Northvolt partnership, and the corpus calls it uncertain[60–62]. AE Elemental's 12,000-tonne plant at Zawiercie in Poland has run since September 2024, with a 25,000-tonne German sister plant planned[63].

Two plants show what carmakers do when they keep the loop themselves. Mercedes-Benz opened Europe's first carmaker-integrated recycling plant at Kuppenheim in October 2024: 2,500 tonnes a year of recovered materials feeding more than 50,000 new battery modules[64]. BMW's Bavarian pilot feeds dismantled production scrap straight back toward cell production[56]. And one plant shows the trap: Li-Cycle's site near Magdeburg shreds 10,000 tonnes a year, but the refining hub it was built to feed never materialised, so its black mass still leaves the region[65,66].

The mid-tier is small: Ecobat runs about 10,000 tonnes across three plants, Duesenfeld about 2,500, Stena industrial-scale capacity in Sweden[37,67]. A national inventory adds operational and pilot sites: SK tes, Primobius, HOPPECKE, Green Li-ion, Nickelhütte Aue and Ecobat's Hettstedt lithium line[16]. Seven of the ten inventoried German facilities sit in North Rhine-Westphalia, where one cluster targets about 120 kt a year of recycling plus 1 GWh (a million kilowatt-hours) a year of second-life storage by 2027-2030[16,17]. Voltfang, the cluster's second-life anchor, runs its Aachen factory at 250 MWh a year today and aims for that 1 GWh by 2030[24,47]. A corpus synthesis calls that 30-35% of Europe's announced pipeline; against the only public announced-capacity count available, 820 kt of refinement announced for 2030, the share does not compute, so we do not repeat it[12,17].

The competition is not other clusters; it is systems. CATL's recycling arm Brunp ran 270,000 tonnes a year of capacity and more than 240 collection depots by end-2024, and processed 120,000 tonnes of used batteries in 2024 into 17,100 tonnes of regenerated lithium salts[58]. Europe's entire operational fleet, at roughly 200 kt, is smaller than this one company[12,58]. Behind Brunp sit China's 78% of global pre-treatment, 89% of black-mass refining, 83% of cell production, and batteries about 40% cheaper than European equivalents[7,68]. Korean refiners' standing bids for black mass, 68-75% of contained metal value delivered to their ports, are the demand signal that keeps European powder moving east[6,14]. The US comparator shows what scale money can buy: Redwood Materials runs more than 80,000 tonnes a year, produced 60,000 tonnes of critical minerals in 2025, and raised $350 million in October 2025 at a valuation above $6 billion[69].

TABLE 3 **The European facility landscape: operating and announced**

Operator	Site	Operating now	Target / announced	Status
Accurec	Krefeld, DE	6,000 t/yr site incl. 4,000 t/yr lithium line	20,000 t/yr by mid-2028; 60,000 t/yr long-term	Li line commissioned 1 Dec 2025, Europe's first industrial Li recovery; expansion permit status conflicting[38,39]
cylib	Dormagen, DE	pilot (Aachen, 500 kg/day)	10,000 t/yr from 2027, then 60,000 t/yr incl. Europe's first industrial LFP line	ground broken Sep 2024; €55M venture round + €89.5M public grants toward more than €180M plant[16,34–36,40]
BASF	Schwarzheide, DE	15,000 t/yr black mass	expansion listed among	commercial since Jun 2025;

Operator	Site	Operating now	Target / announced	Status
			delayed	€460M; prototype refinery 99% Ni / 98% Co[12,37,43]
Li-Cycle (now Glencore)	Sülzetal, DE	10,000 t/yr shredding	30,000 t/yr potential	spoke operating; refining hub never built; black mass leaves the region[65,66]
Mercedes-Benz	Kuppenheim, DE	2,500 t/yr recovered materials	feeds 50,000+ modules/yr	opened Oct 2024; more than 96% recovery claim[64]
BMW / Encory	Salching, DE	mid-double-digit t/yr	pilot	direct recycling of production scrap[56]
Voltfang (second-life)	Aachen, DE	250 MWh/yr	1 GWh/yr by 2030	€250M partnership Sep 2025; ramp rated 30% likely by the corpus[24,47,48]
Umicore	Belgium	25,000 t/yr	150,000 t/yr plant ($525M budget)	operational; mega-plant delayed past 2026[2,12,41,42]
Hydrovolt (Hydro)	Fredrikstad, NO	8,000 t/yr initial + second line (Oct 2024)	300,000 t/yr by 2030, pre-insolvency ambition	Hydro sole owner since Jan 2025; ambition uncertain[60–62]
AE Elemental	Zawiercie, PL	12,000 t/yr	25,000 t/yr sister plant, Wernigerode DE	operational since Sep 2024[63]
Ecobat	DE/UK/US, 3 plants	~10,000 t/yr		operational[37,67]
Duesenfeld	Wendeburg, DE	~2,500 t/yr		operational[16,37,67]
Stena Recycling	Sweden	industrial scale		operational; 95% recovery claim[37,67]
Northvolt Revolt Ett	Skellefteå, SE	closed	125,000 t/yr planned, Europe's largest	bankruptcy Mar 2025; sale process, future uncertain[11,12,70]

Smaller inventoried German sites (SK tes, Primobius, HOPPECKE, Green Li-ion, Nickelhütte Aue, Ecobat Hettstedt) are operational or pilot stage; 7 of the 10 inventoried German facilities sit in North Rhine-Westphalia[16].

Sources:[2,11,12,16,24,34–43,47,48,56,60–67,70].

EXHIBIT 4

Serinyx Quorum evidence ledger; every plotted value traces to a claim id.

06 The bear case: a casualty list with arithmetic behind it

RESTS ON 41 SEPARATELY SOURCED CLAIMS

The strongest evidence against this buildout is not a theory but a casualty list, and recent. Northvolt, Europe's flagship battery maker, went bankrupt in March 2025[11,12]. Its Revolt Ett hub, planned at 125,000 tonnes a year as Europe's largest recycling

plant and only partly operational, went into a sale process with it, taking a prime source of the scrap meant to feed early plants[2,11,12,70]. Li-Cycle failed in May 2025 holding a $475 million US federal loan, after costs at its Rochester refining hub climbed from a $560 million budget to $850 million-$1 billion[21,22]. Construction had been paused since late 2023, leaving five operational shredding spokes with no hub to feed[21,22]. Aqua Metals, a small-cap, saw its repayment plan break on the same lithium fall[22].

The economics beneath them turned first. Lithium carbonate fell from roughly $46,000 a tonne on the corpus's 2023 average (an external assessment reads $40,579; we print the conflict) to about $12,400 in 2024, with near $10,500 forecast for 2025[20]. An independent Fastmarkets series shows the same collapse, down about 45% November to November[37]. Recyclers sell metal; when metal is cheap, margins thin[20]. Forecasters now see partial recovery, $15,000-17,000 in 2026 as the market tips from surplus into a small deficit, but that is a forecast, not a price[71].

The overcapacity arithmetic is stark. Installed European capacity of about 270 kt in 2024 was almost three times the 96 kt of batteries and scrap actually arising[12,37]. The projection runs 420 kt installed in 2026 and 520 kt in 2030[12]. Announced refinement capacity reaches 820 kt by 2030, roughly double the top of the 2030 arisings band[1-3,12]. That is why 200 kt of capacity against 100 kt of waste is famine, not plenty[12]. Many plants run below 10% of capacity for lack of returns, and current European practice is not yet profitable[14]. The feedstock is late rather than absent: regional modelling in our evidence base shows recyclers' demand overtaking locally available supply around 2027 and moving into structural deficit by 2030, with imports within 500 km offering 100-300 kt a year of relief[27]. The year-by-year detail behind that: 50-85 kt available against about 4 kt of recycler demand in 2025, 80-100 kt against 70-80 kt at break-even around 2027, then 120-150 kt nominally available against about 120 kt of demand by 2030[27]. Announced projects keep slipping meanwhile: Umicore's 150 kt plant is delayed, and analysts list Eramet and BASF expansions among the delayed or cancelled[2,12,37,42]. And much of what does return leaves as black mass for better Asian prices, the Magdeburg spoke being the working example[6,14,65,66].

Chemistry adds a leak that may become a flood. The market is shifting toward LFP cells, from about 40% of new EVs in 2024 to a projected 49% by 2030, figures for the whole market, not EU registrations[28]. LFP packs sell at $81 per kWh against $128 for nickel-based packs, and an LFP battery carries 60-70% less recycling value per kWh; its iron and phosphate are often not worth recovering at all[59]. At face value, roughly half the future ore body is worth less than the digging: waste management someone must pay for, not mining[20,28,59].

China's lead compounds. Beyond 78% of pre-treatment and 89% of refining, China held 83% of global cell production in 2024 and makes batteries about 40% cheaper than European equivalents[7,68]. Analysts credit it with a ten-year technology lead in recycling, a characterisation rather than a measurement[68]. Its processors buy recycled material 11-31% cheaper than mined inputs[68]. CATL's claimed recovery rates already beat the EU's 2031 targets[5,58].

The unit economics leave little cushion even for survivors. Practitioners report carmakers unwilling to pay any premium for recycled content, so recyclers compete on cost against virgin supply[72]. Hydrometallurgical plants run near $1.3 per kg of operating cost with margins of $0.4-3.3 per kg, and break even near 7,000 tonnes a year, a scale several European mid-tier plants sit below[37,67,73]. Offtake contracts (pre-agreed purchases of output) are no cure: a buyer's withdrawal idled Ascend Elements' planned Kentucky plant, and a Glencore offtake did not save Li-Cycle[21,22].

The operating environment and the state add drag of their own. German industrial electricity averaged 16.77 cents per kWh in 2024 (10.47 with relief schemes) and has risen since; 82% of battery-industry firms report workforce shortages, and specialist training takes 2-4 years[74]. The EU itself has already slipped, postponing supply-chain due diligence by two years[53]. A €1 billion federal raw-materials fund offering €50-150 million equity tickets had more than 50 applications and not one confirmed approval more than a year after launch[75]. Second-life storage competes for the scarcest packs and has a feedstock problem of its own: the flagship operator pivoted to never-used surplus modules, and the corpus rates its 1 GWh-by-2030 ramp only 30% likely[47,48]. The corpus's own downside case is candid: 60% utilisation, a 10-12 year payback and a net present value as low as minus €20 million, weighted at 20%[19].

The strongest bear case needs no more bankruptcies. Nothing the corpus harvested from the regulation requires quota content to be recycled in Europe; if imports qualify, Chinese refiners holding 89% of capacity can serve the 2031 market from abroad[5,7]. Quotas are amendable law: the corpus's compliance guidance expects targets monitored for revision, and a decade of starving plants is the record a softening would cite[5,14,27]. The bear case reads: volumes real but late, plants real but starving, value real but leaking east, a legal demand servable from abroad or softenable on review[5,6,14,27]. What it cannot do is un-sell the cars: retirement dates stand, and so, for now, do the August 2031 obligations[4,5]. And the take-back duty keeps the waste European even where the value is not: all of it must be collected, at 100%, whatever refining pays[5].

TABLE 4 The price screen recyclers sell into

Series	Values
Lithium carbonate, 2022 spot peak	~$85,000/t[20]
Lithium carbonate, 2023 average	~$46,000/t per the corpus table; external S&P assessment $40,579/t, conflict disclosed[20]
Lithium carbonate, Nov 2023 to Nov 2024	$19.91-21.32/kg falling to $10.56-11.33/kg, about -45%[37]
Lithium carbonate, 2024 average	~$12,374/t[20]
Lithium carbonate, 2025	~$10,542/t forecast; China spot range $8,259-13,003/t[20,71]
Lithium carbonate, 2026 forecast	$15,000-17,000/t; potential later peak near $28,000/t[71]
Lithium market balance	surplus 84 kt (2024) and 33 kt (2025) turning to a 1.5 kt deficit (2026 forecast)[71]
Cobalt	$13.50/lb (2025 assumption) rising to $25.00/lb (2026 forecast); recycled cobalt and nickel 30-40% cheaper than virgin[76]
Nickel	~$14,900/t (Aug 2025); 2025 forecast $15,500-16,000/t; 198 kt surplus; Indonesia 62% of supply; rebalance ~2030[77]
Black-mass payables (Jul 2024, NCM)	73-75% of contained Ni/Co value ex-works US; 68-75% delivered Korea; 3-5% of the lithium price[6]

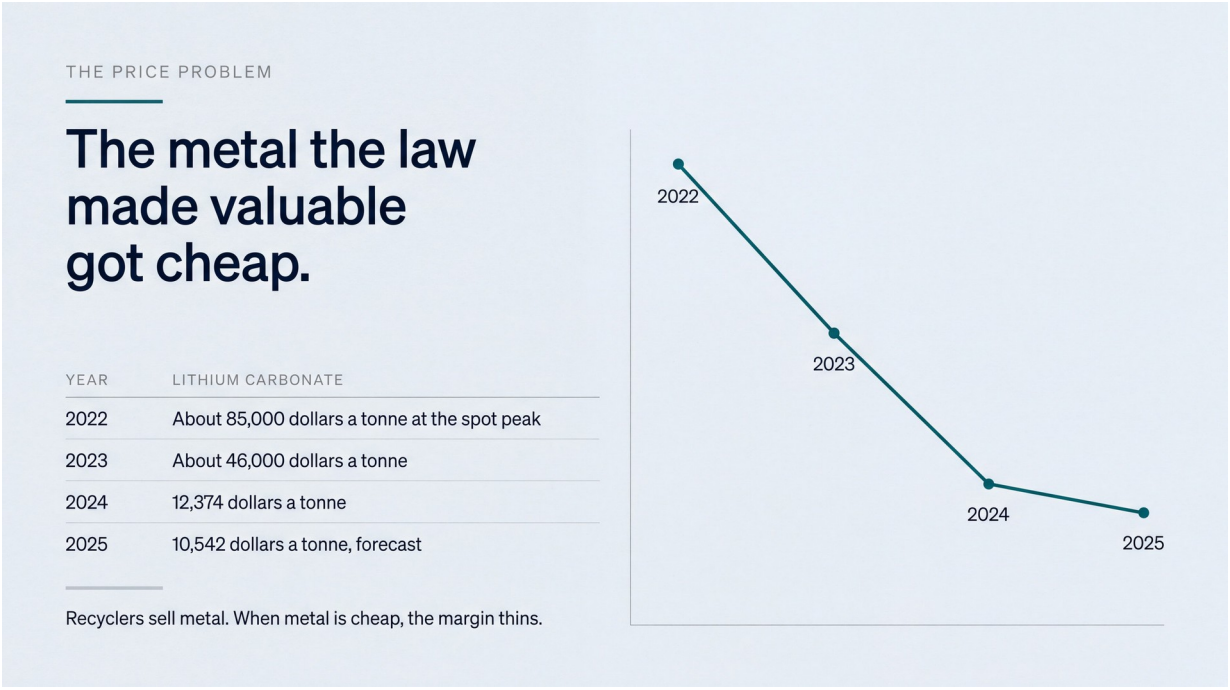
Sources:[6,20,37,71,76,77].

TABLE 5 The bear-case ledger, condensed

#	Evidence	Anchor values
1	Northvolt bankruptcy; Revolt Ett closed	125,000 t/yr planned capacity lost; sale process[11,12,70]
2	Li-Cycle bankruptcy	$475M federal loan; costs $560M to $850M-1B; hub paused since 2023; five spokes, no hub[21,22]
3	Small-cap casualty	Aqua Metals repayment plan broke on the lithium fall[22]
4	Lithium price collapse	~$46,000/t (2023) to $12,374/t (2024) to ~$10,542/t (2025F); independent series -45% Nov to Nov[20,37]
5	Announced-capacity slippage	Umicore 150 kt delayed; Eramet and BASF expansions delayed or cancelled[2,12,37,42]
6	Starvation	many EU plants under 10% utilised; practice not yet profitable[14]
7	Overcapacity arithmetic	installed ~270 kt vs 96 kt arisings (2024); announced refinement 820 kt vs 230-420 kt arisings (2030)[1-3,12,37]
8	Feedstock timing	regional break-even ~2027; structural deficit by 2030[27]
9	Export habit	black mass leaves for higher Asian bids; German spoke ships out for want of a hub[6,14,65,66]
10	Chemistry shift	LFP ~40% to 49% of new EVs by 2030 (whole market); LFP recycling value 60-70% lower per kWh[28,59]
11	China's compounding lead	78% pre-treatment / 89% refining; 83% of cell capacity; recycled inputs 11-31% cheaper; claimed recovery above EU 2031 targets[7,58,68]
12	No green premium	carmakers unwilling to pay up for recycled content[72]
13	Thin unit economics	~$1.3/kg cost; margins $0.4-3.3/kg; break-even ~7,000 t/yr[73]
14	Offtake fragility	buyer withdrawal idled Ascend's Kentucky plant; Glencore offtake did not save Li-Cycle[21,22]
15	Regulatory slippage	due diligence delayed two years to Aug 2027; guidance 17 months late[53]
16	Operating costs and people	German industrial power 16.77 ct/kWh (2024); 82% of firms short of specialists[74]
17	Second-life competition	flagship pivoted to never-used modules; 1 GWh ramp rated 30% likely[47,48]
18	Public-money bottleneck	€1B federal fund: 50+ applications, no confirmed approvals by Jan 2026[75]
19	The modelled downside	60% utilisation, 10-12 yr payback, NPV to minus €20M, at 20% weight[19]

Sources:[1-3,6,7,11,12,14,19-22,27,28,37,42,47,48,53,58,59,65,66,68,70,72-75].

EXHIBIT 5



Serinyx Quorum evidence ledger; every plotted value traces to a claim id.

07 The bottleneck is not chemistry. It is finance.

RESTS ON 24 SEPARATELY SOURCED CLAIMS

Start with what a plant costs. Hydrometallurgical capacity costs about €2,100-2,900 per tonne of yearly processing capacity; the corpus benchmarks lithium mining at $6,000-10,000 per tonne of yearly lithium-carbonate-equivalent output (the industry's lithium yardstick) and calls recycling 3 to 4 times less capital-intensive[18]. We drop the multiple: it compares different tonnes in different currencies, and a tonne of batteries yields a small fraction of a tonne of lithium[10,18].

Returns are the harder problem. For a modelled €450 million programme the corpus weights three cases: an internal rate of return (the yearly return on money put in) of 8-10% at 50% odds, 12-14% at 30%, 4-6% at 20%[19]. The same model's base case runs at 80% utilisation by 2028, a 7-8 year payback and €85-120 million of net present value (today's worth of all future cash)[19]. The optimistic case reaches 90-95% utilisation, 5-6 years and €180-250 million[19]. The pessimistic case sits at 60% utilisation, 10-12 years and minus €20 million to plus €30 million[19]. The blend: an expected €117 million at 9.4%[19]. Corpus verdict: viable with concessional finance, public money on softer-than-market terms, not compelling for private capital alone[19]. Two health warnings stand. The cases assume lithium at €15,000-25,000 a tonne, all above the roughly $10,500 forecast for 2025; the $15,000-17,000 forecast for 2026 would bring the cheapest assumption into reach, but a forecast is not a price[19,20,71]. And none prices a construction overrun, though Li-Cycle's rose 50 to 80% before bankruptcy[19,21,22].

Lithium is the biggest swing: €5,000 a tonne moves returns by 1.5 to 2 percentage points, so the corpus ties bankability to offtake contracts with price floors of at least €16,000 per tonne of lithium carbonate[19]. The floor is in euros, the market in dollars, but even at one-to-one it sits half as high again above the 2025 forecast: the price that makes a project bankable sits far above the price on the screen[19,20]. Nor is a signed offtake a cure, as the bear ledger's Ascend and Li-Cycle rows show; floors hedge price, not counterparty or build[21,22].

The financing that works on paper is a blend. A representative €100 million project stacks 35% private equity expecting 15-20% returns, 30% public senior debt (loans repaid first) at low cost, 20% mezzanine (middle-ranking, riskier debt) and 15% grants[23]. The source blends this to a cost of capital near 4.2%; we print that figure only to disown it, because it cannot be rebuilt from its own components (they imply roughly twice as much), and we log the inconsistency here and in the method box[23]. A related analysis credits each €1 of public anchor money with mobilising roughly €3 to €4 more; modelled, not observed, at moderate confidence[23].

The public instruments exist, each with a cap, a clock and a queue. The EU Innovation Fund's 2025 net-zero call offers €2.9 billion at up to 60% of eligible costs, from €40 million-capped pilots to uncapped projects above €100 million of capex;

applications take 8-12 months to prepare and about a quarter succeed[78]. The affected German region holds a €680 million Just Transition Fund allocation whose flagship call funds up to 40% of costs to a €200 million per-company cap, and the whole programme hard-stops on 31 December 2027[79,80]. The €1 billion federal raw-materials fund offers €50-150 million equity per project and had approved nothing by January 2026[75]. Stacking is capped too: combined grants are limited to roughly 60-70% of eligible costs[81]. A worked €100 million plant stacks a €40 million innovation grant, a €20 million regional grant and €15 million of public equity, and still needs €25 million of private capital on top[81]. The bottleneck is not the menu but the till: the federal fund's only publicly discussed participation, a €150 million position in Vulcan Energy, was still merely planned as of March 2026[75].

What the instruments must fill is now counted borrower by borrower. In North Rhine-Westphalia alone, planned projects need €650 million to €1.05 billion by 2030, of which €510-810 million is not covered by existing financing instruments[25]. A companion synthesis counts €750 million to €1.2 billion on a slightly wider perimeter, and both ranges are flagged[25,82]. Its security split is the sharper finding: the second-life player is 100% covered, the scale-up recycler about 45%, and the established recycler's €100-150 million expansion had nothing secured as of early 2026[82]. The corpus prices the pipeline project by project, from €50 million logistics lines to €300 million ramps[25]. Its deployment model phases €775 million across 2026-2030, peaking at €240 million in 2027: the year the just-transition window closes and both flagship plants need final financing[79,80,83]. Europe-wide, the corpus carries an estimate of €15-20 billion needed by 2030 and more than €50 billion by 2040, but names no external source for it, so we use it as an order of magnitude, not a fact, and disclose that in How we know[26].

Private money is arriving, but next door. cylib has raised a €55 million Series A (a first venture funding round) plus €89.5 million in public grants toward a plant investment above €180 million[34-36]. Voltfang agreed a €250 million partnership with investor Palladio Partners in September 2025, aiming for 1 GWh a year of second-life storage by 2030[24,47]. Second-life is a trade competing for the same packs: every second-lifed pack makes recyclers wait years longer[24,47,48]. The quotas will feed whoever is still standing in August 2031; still standing is first a financing question[5,19].

TABLE 6 **The financing toolbox, generalised**

Instrument	Parameters
EU Innovation Fund, 2025 net-zero call	€2.9B; up to 60% of eligible costs; pilots from €2.5M capex capped at €40M; large projects above €100M uncapped; 8-12 months to prepare; ~25% success[78]
EU Just Transition Fund, regional allocation	€680M; flagship call up to 40% of costs, €200M per company; programme ends 31 Dec 2027[79,80]
Federal raw-materials fund (generalised)	€1B; €50-150M equity per project; launched Oct 2024; 50+ applications, no confirmed approvals by Jan 2026[75]
Grant stacking rule	combined grants capped at ~60-70% of eligible costs; worked €100M stack: 40% + 20% grants, 15% public equity, 25% private[81]
Representative project stack (corpus model)	35% private equity (15-20% target), 30% public senior debt, 20% mezzanine, 15% grants; the source's 4.2% blend fails arithmetic and is disowned[23]
Public-anchor multiplier (corpus model)	each public €1 mobilises roughly €3-4 of total investment; modelled, not observed, moderate confidence[23]

Sources:[23,75,78-81].

7. THE COUNTERWEIGHT: PERHAPS IT IS NOT A MINE AT ALL

The strongest case against this report is not the bear case above; it is a different reading of the same facts. On that reading, battery recycling in Europe is not an emerging extraction industry but a waste-management obligation with a subsidy attached, and the mine metaphor, our own headline included, is the error.

The argument runs like this. A mine's ore has positive value; here, roughly half the future ore body (the LFP share) is worth less than the cost of processing it at current prices[20,28,59]. A market's demand comes from buyers; this one's comes from an amendable statute, and the buyers demonstrably will not pay a premium for the product[5,72]. The statute, as harvested, does not require the work to happen in Europe, while the refiners who already do it best hold 89% of world capacity and claim recovery rates above the EU's own 2031 targets[5,7,58]. Every cost that decides where processing industries live, power, labour, scale, capital, currently favours Asia[68,74]. On this reading, the rational European end-state is the one already observable: collect and shred at home under the 100% take-back duty, export the powder, meet the quotas with imported material if the rules allow, and let the €105 billion market be booked mostly elsewhere[5,6,14,29]. Public money spent on refineries would then buy

strategic comfort, not returns, and the honest name for an 8-10% base case that needs concessional support is industrial policy, not investment[19].

We think that reading is coherent, and this report's own evidence feeds it. What it must still explain away is specific. BASF has run commercially since June 2025, Accurec commissioned Europe's first industrial lithium recovery, and cylib is financed to about 45% of its need with a 2027 start[38,39,43,82]. Mercedes-Benz closes a loop inside its own factory gate, and the Critical Raw Materials Act makes 25%-from-recycling a binding Union-level benchmark for 2030[64]. It must also explain the passport: from February 2027 every large battery carries the record that makes recycled content checkable, plumbing a legislature builds only when it intends to use it[5]. Our reading stands, but on bankability, not inevitability: the volumes and the law are real; whether Europe owns the profitable half is undecided, and the deciding numbers are in section 6[1–3,5,25]. The counterweight's service is to name the failure mode precisely: if in 2031 the quotas are met with imported salts while European plants still starve, this report's mine will have been a landfill with paperwork[5,7,14].

08 Method: how the numbers were made, and the ones we refused to print

RESTS ON 21 SEPARATELY SOURCED CLAIMS

Three families of numbers appear in this report. External figures (prices, capacities, dates) are relayed from named assessments, legal texts and company announcements through the research corpus, each carrying a claim tag[20,41,42]. Adjudicated figures passed a corpus-level check: consensus bands across multiple sources, or official texts read directly[1–3,5]. Modelled figures are the corpus's own constructions, the scenario economics, the regional feedstock balance and the deployment curve among them, and the text labels them as models wherever they do work[19,27,83]. Tables carry a Sources line covering every cell, and each figure anchor lists every plotted value with its claim id, so the charts are checkable without the text.

Conflicts between source files were resolved by a standing rule: the deeper, later-sourced file wins, and the conflict is logged. That rule dated Northvolt's bankruptcy to March 2025 over a 2024 variant, preferred 93.8% to 98% for CATL's lithium-recovery claim, chose September 2025 for the Voltfang partnership, and set aside a Hydrovolt capacity figure fifteen times its primary-sourced value as a suspected decimal error[11,12,24,47,58,60–62].

Some numbers we refused to print as fact. A 4.2% blended cost of capital fails arithmetic against its own components[23]. A 3-to-4-times capital-intensity multiple compares different tonnes in different currencies[18]. A 30-35% share of Europe's announced pipeline has no verifiable denominator[12,17]. An earlier set of recycling-coverage shares (9.9% of lithium demand and kin) sat on an unstated demand base and was replaced by sourced shares with a named base[2,13]. A $1.7 billion lifetime-raise figure for Li-Cycle was weakly sourced, so only its verified elements appear[21,22]. A Chinese capacity figure of 423 million tonnes a year looked like a unit error and was left unmapped. Two conflicts we could not resolve are printed as conflicts: the 2023 lithium average and the 2025-versus-2027 efficiency step date[5,20].

Client firewall: the corpus behind this report was originally researched around a German public financing institution. Its name, products and framework vocabulary are removed throughout; its instruments appear only as generalised types (public senior debt, public anchor financing, a federal raw-materials fund); regional statistics appear as public geography only[25,75].

HOW WE KNOW

This report showcases bankability analysis, one half of its registry capability 'bankability and impact-metrics' (the other half is not demonstrated): the returns, capital-intensity, financing-stack, secured-share and investment-gap figures above restate the corpus's modelled project economics for the public.

The draft comes from a claim map of 100 claims drawn from twenty-seven files of a dedicated battery-recycling corpus, read in two rounds: a first harvest of seventeen files and an expansion of ten more for this substantial edition. Every factual sentence above carries a tag traceable to a source file. Claims are marked adjudicated (checked across multiple external sources, official legal texts, or the corpus's verified models), published (relayed without such a check) or dossier (facilities data). Where sources conflicted (the Northvolt date, the Hydrovolt capacity, the CATL recovery claim), the deeper, later-sourced file won and the conflict was logged; the two conflicts we could not resolve are printed as conflicts in the text[5,20]. Evidence cut-off: 2026-09-02. 66 of the 100 claims rest on figures that may have moved; all are flagged for re-checking before publication.

The first edition of this report passed through a four-seat adversarial review (fact, adversary, layman, editor) that filed 98 findings, ten of them blocking, each resolved and re-reviewed. Those fixes bind this edition too: the corrected

handles, the disowned figures and the narrowed claims above all originate there. One source figure, the 4.2% blended cost of capital, failed arithmetic against its components and appears above only to be disowned[23].

The fleet, plainly: production staffs drafting and review from at least two model vendors; this pilot ran every seat on one vendor's models, so independence was procedural, cold reads with no shared context, not architectural. The corpus does not record how many models collected its research; we log the gap rather than guess.

What we could not establish: whether the quotas require material recycled in Europe (the harvested regulation does not say; calculation rules follow in Commission acts); an external source for the corpus's €15-20 billion EU-wide estimate[26]; the gigafactory scrap rate (share of production scrapped, distinct from scrap's 75% feedstock share); black-mass export tonnages; a measured EU collection rate for EV batteries (the 100% take-back duty is law, not an observation)[5]; and used-EV outflows before retirement. Nor could we establish: any analysis of an EU restriction or reclassification of black-mass exports; plant-level utilisation beyond the corpus's under-10% characterisation[14]; the geographic basis of the 65.6% hydrometallurgy share[55]; and the terms of any signed offtake contract. Where these absences matter, the text says so.

WHAT WOULD CHANGE OUR MIND

Four observations that would overturn this report, and where to watch.

1. **The quotas move.** If the August 2031 requirements slip, shrink or gain exemptions, the manufactured market softens[5]. Watch: delegated and implementing acts under Regulation 2023/1542 (the Commission's follow-on rules), with the two-year due-diligence delay as the precedent[5,53].
2. **The powder keeps leaving, or content comes in.** If black mass still flows east at a premium once European refining opens, or imports satisfy the quotas, the value leaves as the market grows[5-7,14]. Watch: EU waste-shipment and trade rulings, and the first published export tonnages (a series we lack).
3. **Chemistry outruns the economics.** If LFP passes its projected 49% of new EVs by 2030 while lithium stays near $10,500 a tonne, the average retired battery may not be worth refining[20,28]. Watch: the chemistry mix of new EU registrations (absent from the corpus), and lithium assessments against the $15,000-17,000 forecast for 2026[71].
4. **Private money funds refining unaided.** If equity and bank debt start closing European refining financings without grants or public anchors, the concessional-finance verdict fails, and with it this report's reading of who decides the race[19,82]. Watch: the €1 billion federal fund's first approvals, Innovation Fund award lists, and whether the established recycler's unsecured €100-150 million expansion finds terms[75,78,82].

09 Small print

AI disclosure. Researched, drafted and checked by Quorum, Serinyx's adversarial AI research pipeline, from a fixed evidence corpus under a brief locked by a human editor; every factual sentence carries a claim tag, and human gates review facts, fairness and clarity before publication. **Corrections.** We correct promptly and log every change against the claim map.

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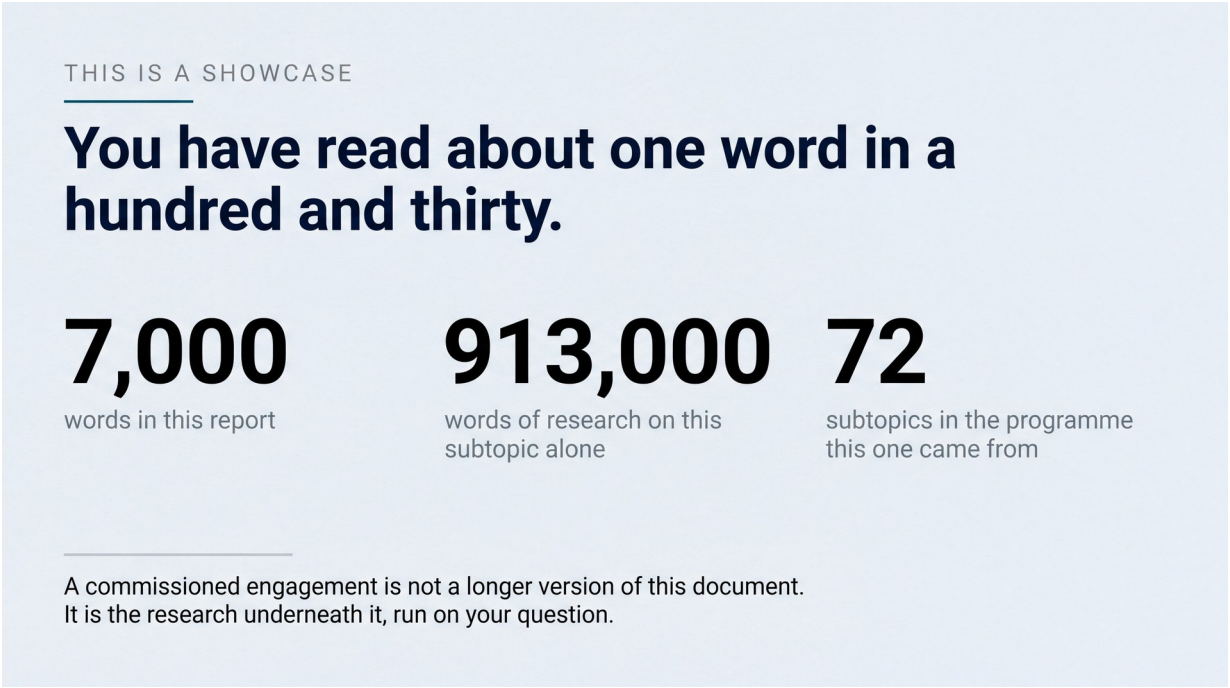
ABOUT THE RESEARCH CORPUS

This report is a summary of a much larger evidence base. The figures below state the size of the research corpus synthesised here, measured on the working corpus at build time.

Topic research corpus	285 files · 41 MB · approximately 913,000 words on circular-economy value chains
Wider programme	A 12-field, 72-subtopic research programme on the industrial transition
Distilled into this report	100 tagged claims across two harvest rounds
Independently referenced	83 references; 61 verified or relocated links, 4 live but access-restricted
Review before release	4 external review seats plus a consolidated review · 98 findings resolved · 7 gates passed

Corpus word counts cover machine-readable text files; total sizes include datasets and rendered assets. Sources marked adjudicated passed the source study's own multi-model verification before this report used them.



THIS IS A SHOWCASE

About one word in a hundred and thirty of the research behind it.

This report runs to roughly 7,000 words. It is a summary of one subtopic in a research programme of 12 fields and 72 subtopics; the battery-recycling subtree alone holds approximately 913,000 words of research across 285 documents and datasets.

What you have read here is a showcase. It demonstrates a handful of Quorum's capabilities on a topic chosen to be legible in twenty minutes. A commissioned engagement is not a longer version of this document; it is the research underneath it, run on your question, with your sign-off on the brief and a full audit trail you can hand to a board or an investment committee.

For a full piece of research or advisory work, contact Lorenz at lorenz@serinyx.com.

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