

Pacepoint

OCTOBER 2026

FROM MINE TO MOTOR

What it takes to build an electric vehicle,
and where mineral-rich economies can capture value.

Mineral endowment is an opportunity, not an industrial strategy.

An illustrated briefing for governments, investors, development finance institutions and industry.

Kenneth Ene
Pacepoint Advisory

THE JOURNEY IN BRIEF

From mine to motor

Why critical minerals matter to the electric vehicle transition

An electric car is more than a battery on wheels. It is the end product of a global journey that starts with minerals, passes through specialised factories, reaches our roads and increasingly comes back again.



01 MINE

Lithium, graphite, nickel, copper and other minerals are extracted from the earth.



02 MAKE

Minerals are refined and turned into battery materials, cells, motors and wiring.



03 DRIVE

Those components become vehicles that run without tailpipe emissions.



04 RECYCLE

Batteries and factory scrap are recovered to supply new materials, a source that grows as today's EVs reach the end of their life.

RECOVERED MATERIALS RETURN TO SUPPLY

FIVE MATERIALS, FIVE DIFFERENT JOBS

Li — **LITHIUM**
helps store energy in today's mainstream EV batteries.

C — **GRAPHITE**
is used in the anodes of most lithium-ion batteries.

Ni Co — **NICKEL AND COBALT**
are used in some battery types, but not all.

Cu — **COPPER**
carries electricity through motors, cables and charging systems.

Nd — **RARE EARTHS**
make powerful magnets for many EV motors, though some motors do without them.

THE BIGGER STORY

- EVs cut oil use and tailpipe emissions, with larger lifecycle benefits as electricity gets cleaner.
- But scaling them up means building **reliable, responsible** mineral supply chains. Mining is only the first step: refining and battery manufacturing are often concentrated in fewer countries.
- There is **no single winning battery recipe**. Some batteries use nickel and cobalt; others use iron and phosphate. Technology, recycling and smarter design can change which minerals we need and how much.

THE TAKEAWAY

The EV transition is also a minerals transition.

The opportunity is **not simply to dig more**, but to build cleaner, more diverse supply chains and capture lasting value along the way.

Sources: IEA, *Global EV Outlook 2026* and *Global Critical Minerals Outlook 2026*.

PACEPOINT ADVISORY

REPORT AT A GLANCE

An EV is a materials story as much as a technology story

An electric vehicle (EV) may be assembled in Europe, but the minerals that make it work can travel through several countries before reaching the factory. Lithium might be mined in Australia and refined in China. Graphite could come from Mozambique before being processed into battery material elsewhere. Copper, nickel and rare earths follow their own routes through a complex global supply chain.

But the story is changing. Not every EV uses the same minerals. Some batteries need nickel and cobalt, while others use neither. Some motors depend on rare earths, while others avoid them entirely. So what does it actually take to build an electric vehicle, and which countries and companies are best positioned to benefit? This report traces minerals from extraction to manufacturing and examines what the evolving EV industry means for resource-rich economies.

1.2 TWh

EV battery deployment, 2025

Battery capacity fitted to new EVs sold worldwide. A measure of **demand**, not factory output. Up almost 30% on 2024.

Source: IEA GEVO 2026

>55%

LFP share of new EV batteries, 2025

Share of new EV battery capacity (GWh) using lithium iron phosphate, which needs **no nickel or cobalt**.

Source: IEA GEVO 2026

>80%

China's share of battery manufacturing, 2025

Of global cell **capacity** (what factories could make) *and* of **production** (what they did make).

Source: IEA GEVO 2026

~3%

Critical minerals' share of EV price

Cost of critical minerals in the vehicle ÷ price of an average EV. Small in the price tag, decisive in the supply chain.

Source: IEA GCMO 2026

Deployment measures battery demand; manufacturing capacity and output measure potential and actual production. The ~3% estimate is an IEA estimate (Global Critical Minerals Outlook 2026).

THREE MESSAGES

1 **There is no single mineral recipe for an EV**

Battery chemistry and motor design change which minerals matter, and technology continues to reshape demand.

2 **Mining is only one part of the supply chain**

Refining, battery materials and manufacturing can be highly concentrated, creating vulnerabilities beyond the mine.

3 **Mineral endowment creates an opportunity, not an automatic industrial advantage**

Countries capture lasting value where they can build commercially competitive capabilities.

PACEPOINT ADVISORY

CONTENTS

Inside this briefing

HOW TO USE THIS REPORT

Sections 1–3 explain the vehicle and its supply chain. Section 4 follows five mineral journeys. Section 5 examines changing demand and recycling. Section 6 presents a practical competitiveness framework and four country examples. Section 7 sets out implications for decision-makers.

01 **Why now?** 05
How governments are reshaping critical-mineral supply chains

02 **The EV is a mineral product** 08
The minerals inside an electric car, and why chemistry matters

03 **From mine to motor** 12
The hourglass: why processing is the bottleneck

04 **Five mineral journeys** 16
Lithium, graphite, nickel and cobalt, copper, rare earths

05 **The mineral map is changing** 20
Chemistry, efficiency, recycling and demand to 2040

06 **Beyond extraction** 24
Where mineral-rich economies can capture value

07 **So what?** 30
Implications by audience, and conclusion



PACEPOINT ADVISORY



SECTION ONE

WHY NOW?

Critical minerals have moved from a specialist mining issue to the center of debates about industrial competitiveness, energy security and trade.

01

SECTION 01

Why now?

Critical minerals have moved from a specialist mining issue to the center of debates about industrial competitiveness, energy security and trade. The rapid growth in EV battery deployment is driving demand for critical minerals, but evolving battery technologies are changing which minerals are needed and in what quantities.

Lithium iron phosphate (LFP) batteries have gained market share, while processing and manufacturing capacity remain concentrated in a small number of economies.

Governments are responding in different ways. Some producer countries use export restrictions and processing incentives to encourage domestic investment. China has introduced export controls on selected materials and technologies. Consumer economies are supporting supply diversification through industrial policy, strategic partnerships and public financing. These measures differ in legal status and implementation, and should not be treated as interchangeable.

Yet this is not simply a story of scarcity. Manufacturers are improving material efficiency, alternative battery chemistries are entering the market and recycling is expanding. The strategic challenge is to build supply chains that remain viable as technology, trade rules and prices change.

Figure 1 shows three broad approaches governments are taking: capturing more value domestically, controlling strategic supplies and diversifying supply chains. Producer-country measures, such as export bans and requirements for local processing, need to be assessed against their commercial viability rather than treated as strategies that will necessarily deliver greater domestic value. Section 6 examines this in more detail.

> The EV transition is not just a race to secure minerals. It is a challenge to build supply chains that remain viable as technology, trade rules and prices change.



FIGURE 1

How governments are reshaping critical-mineral supply chains

1 CAPTURE MORE VALUE

Producer economies encourage domestic processing and greater value addition.

CL — Apr 2023 — Chile

National Lithium Strategy: greater state participation, public–private partnerships and support for local value addition.

Policy adopted

DRC — Feb 2025 — Democratic Republic of the Congo

Suspends cobalt exports; a quota system replaces the suspension in October 2025.

Quotas in force

ZW — Feb 2026 — Zimbabwe

Suspends raw-mineral and lithium-concentrate exports, bringing a planned 2027 ban forward.

In force

Also: Indonesia (2020) · Zimbabwe (2022) · Namibia (2023)

2 CONTROL STRATEGIC SUPPLY

Export licensing and restrictions can influence access to strategically important minerals and materials.

CN — Dec 2023 — China

Export licensing for graphite products takes effect.

In force

CN — Apr 2025 — China

Export controls on seven medium and heavy rare earths and related magnets.

In force

CN — Oct 2025 — China

Expanded rare-earth and battery-material controls announced; implementation of the October measures suspended for one year. Earlier controls remain in force.

Suspended to 10 Nov 2026

Also: Tariff codes under Chinese export controls tripled since 2023 (IEA)

3 DIVERSIFY SUPPLY CHAINS

Consumer economies respond with policy frameworks, industrial investment, stockpiles and price support.

EU — May 2024 — European Union · *Policy framework*

Critical Raw Materials Act. By 2030: 10% extraction, 40% processing and 25% recycling benchmarks; no more than 65% dependence on any single third country at a relevant processing stage.

In force

US — Jul 2025 — United States · *Industrial capacity*

Department of Defense equity investment in MP Materials to expand domestic rare-earth magnet production.

Investment agreement in effect

54 — Feb 2026 — US + 53 countries · *Stockpiles & price support*

Washington ministerial: FORGE partnership launched, price-floor arrangements proposed and US$10bn Project Vault stockpile initiative reported.

FORGE launched

Price floors proposed

Project Vault reported

Also: US Inflation Reduction Act (2022) · US–Australia framework (2025) · EU RESourceEU (2025) · Quad (2026)

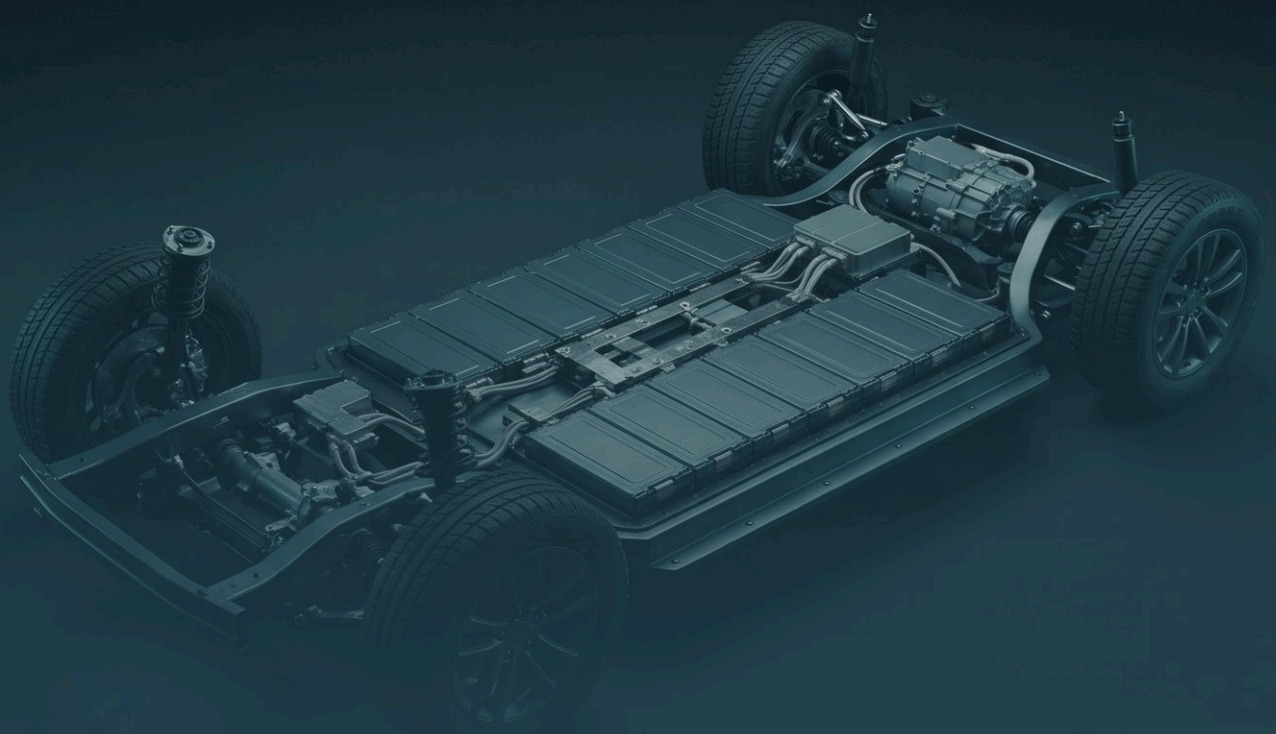
In force / adopted · Proposed or announced · Suspended

Status as of October 2026

Sources: IEA, *Global Critical Minerals Outlook 2026*; Regulation (EU) 2024/1252 and 2023/1542; Pillsbury (November 2025); King & Spalding (June 2026); The Conference Board (February 2026); Al Jazeera (February 2026). Policy status as of October 2026.

PACEPOINT ADVISORY

Pacepoint



SECTION TWO

THE EV IS A MINERAL PRODUCT

The engine, fuel tank and exhaust are replaced by a battery pack, an electric motor, power electronics and high-voltage wiring.

02

SECTION 02

The EV is a mineral product

An electric car resembles a conventional car, but its propulsion system is different. The engine, fuel tank and exhaust are replaced by a battery pack, an electric motor, power electronics and high-voltage wiring. These changes affect which minerals matter and how much of each is needed.

FIGURE 2

Electric cars use substantially more critical minerals than conventional cars (2021 reference vehicles)

Electric car
75 kWh NMC 622 battery, graphite anode

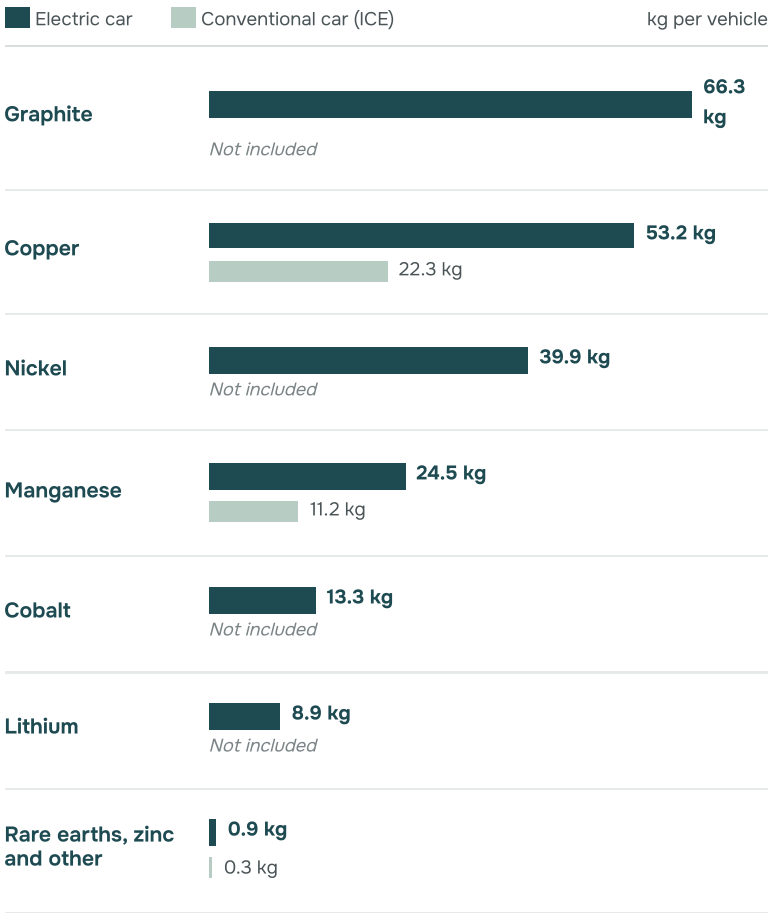
~207 kg
of selected minerals per vehicle

Conventional car
Internal combustion engine (ICE)

~34 kg
of selected minerals per vehicle

About six times as much of the selected minerals

Battery materials (graphite, nickel, manganese, cobalt and lithium) account for about **80%** of the 173 kg gap; copper accounts for most of the rest (**~31 kg**).



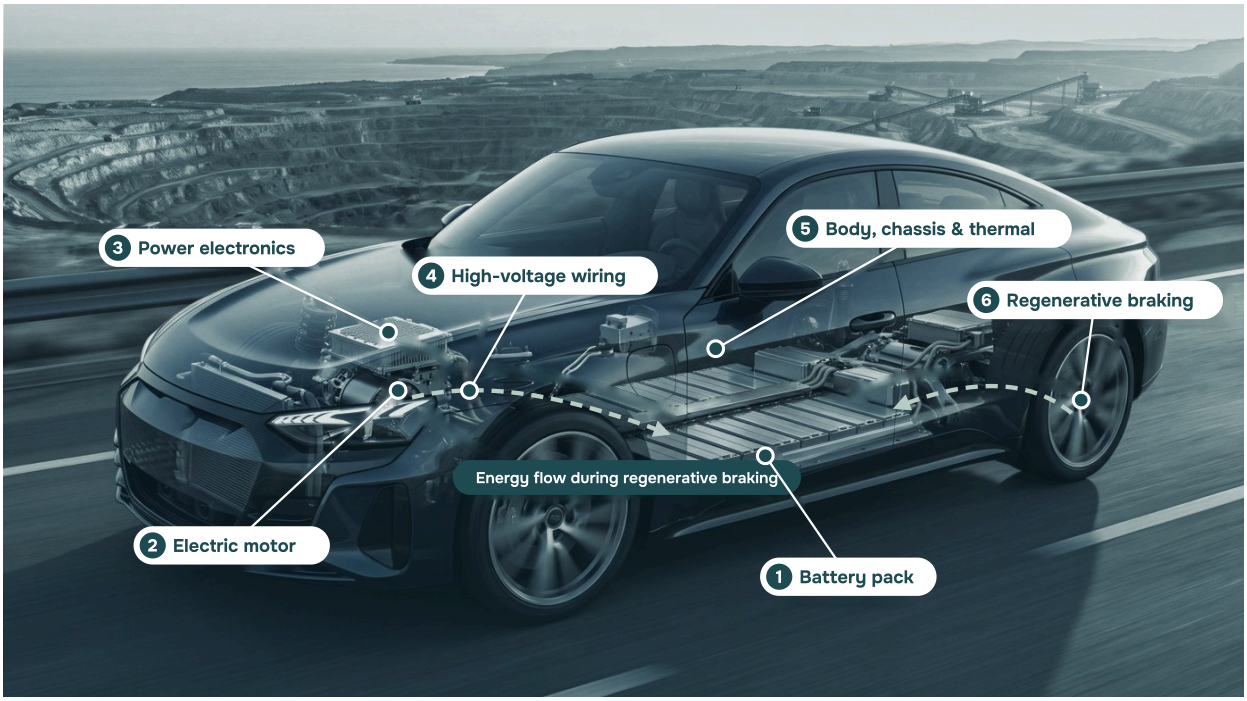
Source: IEA (2021), *The Role of Critical Minerals in Clean Energy Transitions*. Note: IEA 2021 reference vehicles. Figures exclude steel and aluminum. Values are rounded and expressed in kg per vehicle. "Not included" means the mineral is not included for the conventional car in the IEA reference comparison. The reference EV uses a 75 kWh NMC 622 battery with a graphite anode; an LFP battery would replace nickel, cobalt and manganese with iron and phosphate.

All lithium-ion EV batteries use lithium, and most use graphite-based anodes. The other materials used in the cathode vary by battery chemistry. Nickel-manganese-cobalt (NMC) batteries use those three metals in different proportions. Lithium iron phosphate (LFP) batteries use iron and phosphate instead of nickel, manganese, and cobalt.

Battery chemistry, therefore, affects mineral demand, cost, performance, and supply-chain exposure. Figure 3 shows where different materials are used across the vehicle, from the battery pack and traction motor to the electronics, wiring and body.

FIGURE 3

Anatomy of an EV



1 Battery pack

Stores electricity to power the motor. Typically uses lithium-ion batteries.

Lithium	Cathode and electrolyte of mainstream lithium-ion batteries
Graphite	Anode
Nickel, manganese, cobalt	NMC cathode (in many battery chemistries)
Aluminium	Cell casing, module and pack structure
Iron & phosphate	LFP cathode (in some chemistries)
Copper	Anode foil, connectors and busbars

2 Electric motor

Converts electrical energy into mechanical energy to drive the wheels. Many EVs use permanent magnets, though alternative motor designs do not.

Copper	Motor windings and connectors
Electrical steel	Motor core (iron with silicon)
Rare earths	Used in some permanent-magnet motors (neodymium, praseodymium, dysprosium, terbium), **not all EVs**

3 Power electronics

Controls the flow of electricity between the battery and motor, and manages charging and regenerative braking.

Copper	Busbars, wiring and electrical connections
Aluminium	Heat sinks and housings
Silicon / silicon carbide	Power semiconductors in the inverter and on-board charger

4 High-voltage wiring

Carries high-voltage electricity between the battery, inverter, motor and other systems.

Copper	High-voltage cables, busbars and connectors
Aluminium	Some wiring harnesses, as a lower-weight alternative

5 Body, chassis & thermal

Provides structural support and manages heat from the battery, motor and power electronics.

Steel	Body and chassis structures
Aluminium	Body panels, chassis parts, heat exchangers and cooling plates
Copper	Cooling components: radiators, heat exchangers, coolant lines

6 How regenerative braking works

Recovering energy when the vehicle slows

When an EV slows down, its electric motor operates as a generator, converting some of the vehicle's kinetic energy into electricity. The inverter converts this power and returns it to the battery. Conventional friction brakes provide additional stopping power when required.

Mineral implications

Regenerative braking reuses the motor (2), power electronics (3), high-voltage wiring (4) and battery (1), so it requires no additional critical minerals. It also reduces wear on the friction brakes, which means less brake material consumed and fewer brake-particle emissions.

KEY TAKEAWAY

Regenerative braking is a function of the EV's existing systems, not a separate source of mineral demand.

Source: Author's schematic based on IEA (2026). Not to scale; materials shown are principal uses, not a complete bill of materials.

PACEPOINT ADVISORY

The battery is only part of the story. Copper is used in motors, wiring, and power systems. Steel and aluminum remain central to the vehicle body. Many traction motors use permanent magnets containing neodymium and praseodymium, sometimes with dysprosium or terbium. Other motor designs, including induction motors and motors that use electromagnetically generated magnetic fields rather than permanent magnets, eliminate the need for rare earths.

FIGURE 4

Why battery chemistry matters for mineral demand

	Lithium	Graphite (anode)	Nickel	Manganese	Cobalt	Iron	Phosphate
NMC Nickel-manganese-cobalt	✓	✓	✓	✓	✓	–	–
LFP Lithium iron phosphate	✓	✓	–	–	–	✓	✓

>55%

LFP share of new EV battery capacity (GWh) in 2025, up from nearly 50% in 2024

>40%

How much cheaper LFP battery packs were per kWh than NMC packs, on average, in 2025. Covers all applications, including stationary storage; prices vary by manufacturer, design and market.

Energy density

NMC generally stores more energy per kg, supporting longer driving ranges.

Cost, durability and safety

LFP has lower material costs, longer cycle life and greater thermal stability. Performance varies by design and operating conditions.

What's next?

Lithium manganese iron phosphate (LMFP) adds manganese to LFP; sodium-ion batteries use **no lithium at all**. Both are emerging and could gain share.

Source: IEA, *Global EV Outlook 2026*. Battery chemistry characteristics based on established lithium-ion battery technologies. The >40% LFP price advantage covers all applications, including stationary storage.

> An EV is not “a lithium car”. It is a system of materials, and the mix changes with every engineering choice.





SECTION THREE

FROM MINE TO MOTOR

Between geology and the finished vehicle are extraction, concentration, refining, chemical conversion, materials production and manufacturing.

03

SECTION 03

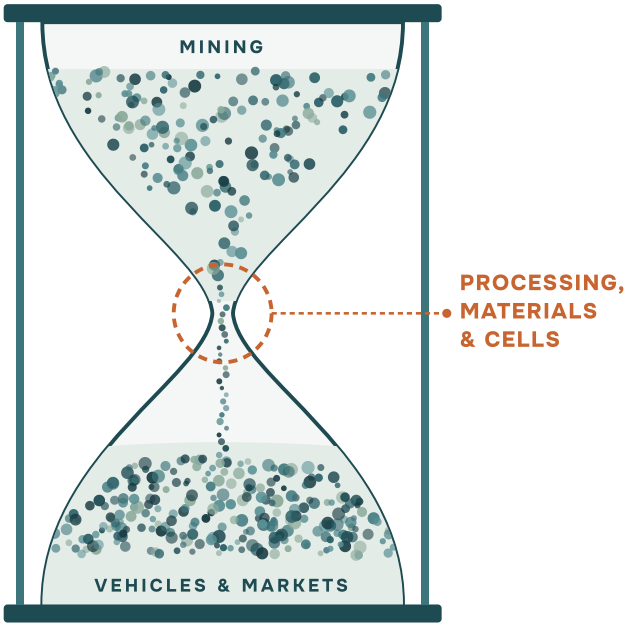
From mine to motor

A mineral deposit does not become a battery simply because it exists underground. Between geology and the finished vehicle are extraction, concentration, refining, chemical conversion, materials production and manufacturing. Each stage demands different combinations of capital, power, technology, skills, environmental controls and market access.

A useful way to understand the chain is as an hourglass. Mining occurs in many countries and vehicles are assembled and sold across major markets. In between, several refining, battery-materials and cell-manufacturing activities are concentrated in relatively few locations. The narrowest stages often create the greatest supply-chain vulnerabilities, although extraction can also be a constraint for particular minerals.

FIGURE 5

Why processing is often the critical bottleneck in EV supply chains



MINING

Mineral extraction is spread across many countries, although **some minerals are more concentrated than others**.

The leading lithium-mining country supplies about **37%** of mined output.

PROCESSING, MATERIALS AND CELLS

Refining, battery-material production and cell manufacturing are **often concentrated in fewer countries**. Export controls and other policy measures can create bottlenecks at this stage.

Across key energy minerals, the leading refining country for each mineral accounted for an average of about **72%** of refined supply in 2025. China accounts for **over 80%** of global battery cell manufacturing capacity.

VEHICLE MANUFACTURING AND MARKETS

Vehicle assembly and sales are **more geographically distributed**, with production and markets in many countries.

Opening mines alone does not remove bottlenecks in processing, materials and cells.

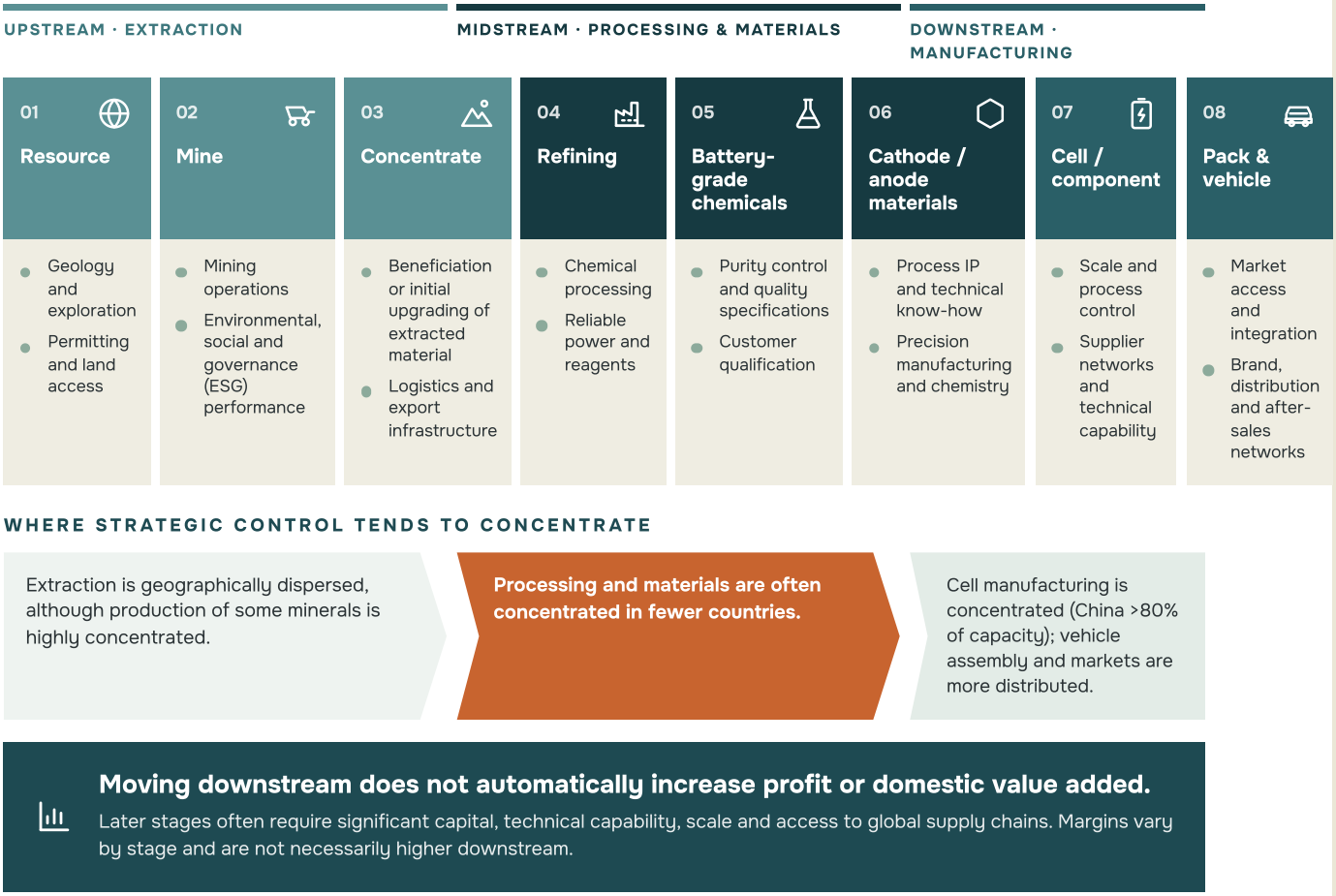
Sources: IEA, *Global Critical Minerals Outlook 2026* and *Global EV Outlook 2026*; USGS, *Mineral Commodity Summaries 2025*. Conceptual illustration; widths are not proportional to volumes. Percentages refer to different measures and should not be compared directly.

The chain in Figure 6 helps explain why mineral-rich countries do not automatically dominate downstream industries. For many battery materials, refining and active-material production are more geographically concentrated than mining. Graphite may be mined in Mozambique, processed into battery-grade anode material in China, incorporated into cells elsewhere and eventually installed in vehicles sold in Europe. Similar distinctions matter for lithium chemicals, nickel sulfate and rare-earth magnets.

Understanding where supply chains are concentrated is only part of the picture. Each stage also requires different capabilities, from mining and chemical processing to battery material production, cell manufacturing, and vehicle assembly. Figure 6 maps these stages and shows why moving downstream does not automatically mean capturing more economic value.

FIGURE 6

Where value is created, and why capabilities matter across the EV supply chain



Source: Author's illustration based on IEA (2026), *Global Critical Minerals Outlook 2026*, *Global EV Outlook 2026*, and industry value chain analysis. Stages are simplified and vary by mineral, battery chemistry, and production route.

> Supply-chain concentration and economic value capture are not the same thing.

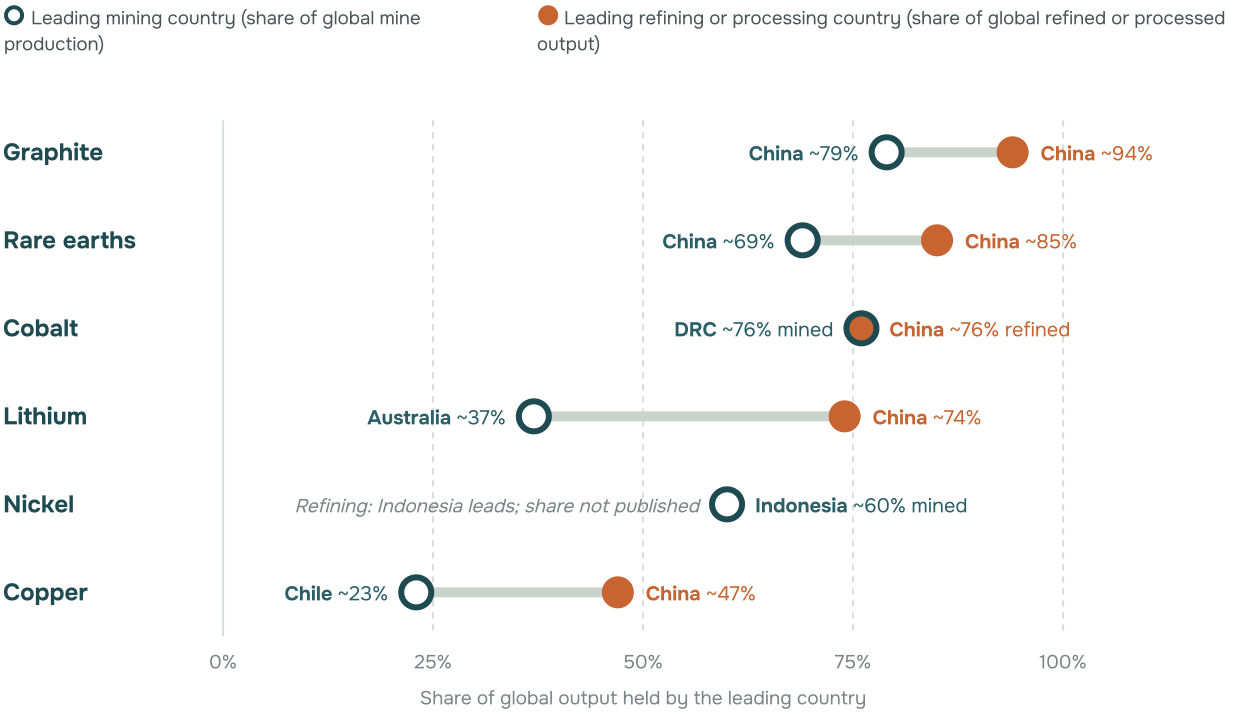
A country may control an important processing stage without necessarily earning high profits from it. Equally, a competitive mining industry can generate substantial economic value through taxes, jobs, local procurement and infrastructure. The key question is where a country can build competitive and sustainable industries that generate lasting economic value, not simply how many processing stages it can host.

The geographic evidence reinforces this distinction. As Figure 7 shows, mining and refining are concentrated in different countries, and processing is often more geographically concentrated than extraction. According to the IEA, excluding rare earths, the leading refining country for each key energy mineral accounted for an average of around 72% of global refined supply in 2025. Indonesia (nickel) and China (most other key energy minerals) also accounted for more than three-quarters of the growth in refined supply between 2023 and 2025.

Graphite illustrates how this works. It may be mined in Mozambique, purified and processed into anode material in China, incorporated into a battery cell in Korea, and installed in a vehicle sold in Europe. In this example, the main supply-chain bottleneck lies in processing and anode production rather than extraction. Similar challenges arise in producing battery-grade lithium chemicals, nickel sulfate for certain battery cathodes, and separated rare-earth products and magnets.

FIGURE 7

Why mineral processing is more concentrated than mining



WHAT THE MEASURES SHOW

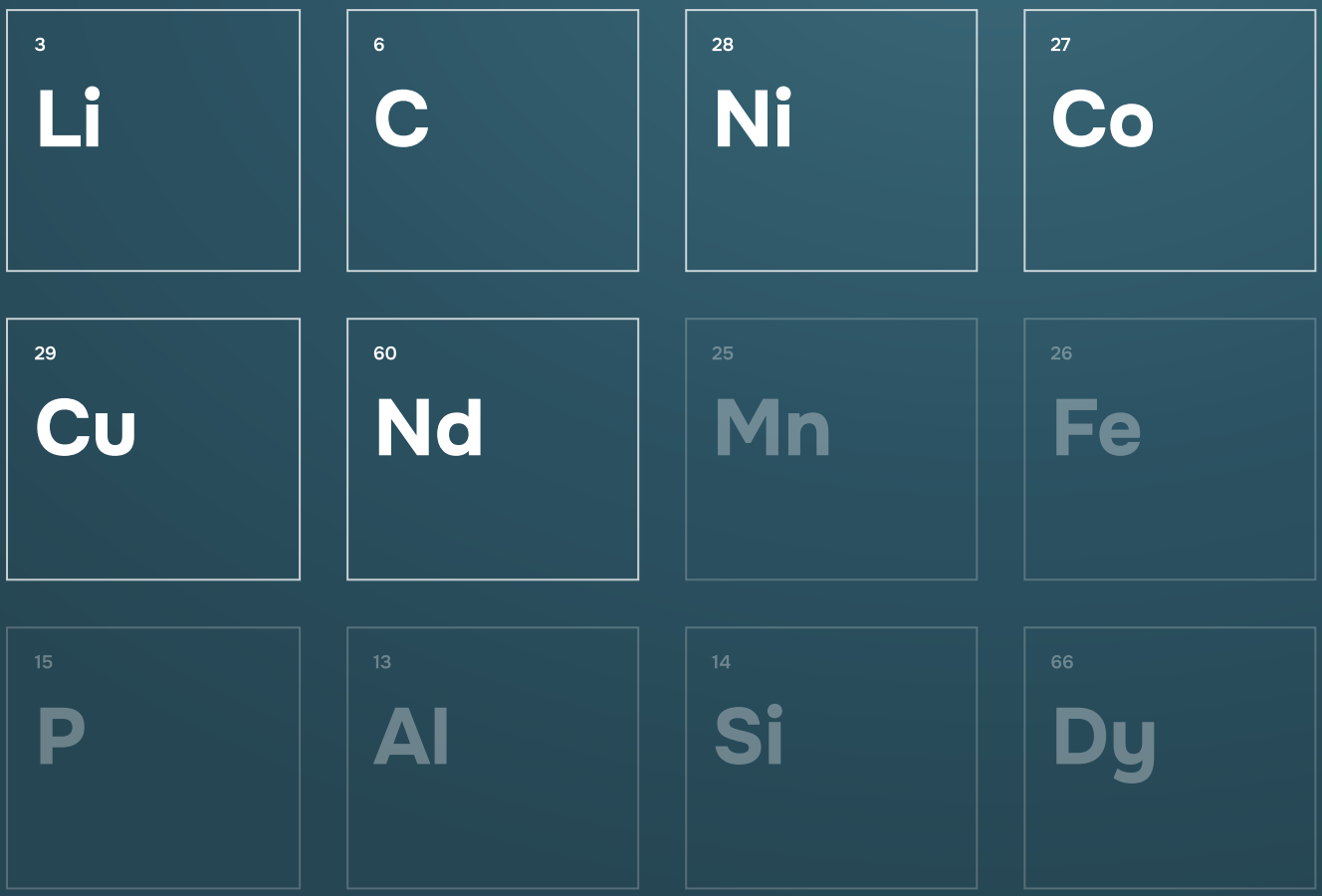
- **Mining:** share of global mine production, 2024 (USGS). Graphite mining refers to natural graphite.
- **Refining or processing:** share of global refined or processed output, 2024–25 (IEA). Graphite refers to battery-grade graphite; rare earths to rare-earth refining; cobalt to refined cobalt.
- Shares are rounded and directional. Nickel refining is not plotted: the sources used report China's share (31%) but not that of Indonesia, the leading refiner.

KEY TAKEAWAYS

- Refining is **more geographically concentrated** than mining for most of the minerals shown.
- China is the leading refiner for **five of six** minerals; Indonesia leads nickel.
- Lithium shows the widest gap: mined mainly in Australia and South America, refined mainly in China.

Sources: IEA, *Global Critical Minerals Outlook 2026*; USGS, *Mineral Commodity Summaries 2025*; BOFIT, *Weekly Review* 32/2026. Note: Mining shares refer to different stages of production and reporting periods. They illustrate geographic concentration rather than directly comparable market shares; refining and processing shares refer to 2024–2025. Shares are rounded. Refining shares are reported in BOFIT Weekly Review 32/2026.

Pacepoint



SECTION FOUR

FIVE MINERAL JOURNEYS

Chemistry, processing, substitution, geography and demand beyond the battery shape the commercial opportunity.

04

SECTION 04

Five mineral journeys

Five mineral stories capture most of the strategic questions behind EV supply chains. Together, they show how chemistry, processing, substitution, geography and demand beyond the battery influence commercial opportunities.

FIGURE 8

Five minerals, five different EV supply-chain stories

Li — Lithium
The battery constant

EV APPLICATION
Cathode and electrolyte of mainstream lithium-ion batteries (NMC, LFP and others).

MAIN SUPPLY GEOGRAPHY
- **Mining** Australia ~37%
- **Refining** China ~74%

KEY PROCESSING CONSTRAINT
Converting spodumene or brine into battery-grade lithium carbonate or hydroxide at consistent purity.

TECHNOLOGY OR MARKET SHIFT
Prices more than doubled through 2025 and early 2026, after several years of decline, as reported by the IEA. Sodium-ion is emerging in some lower-cost segments.

C — Graphite
The anode material

EV APPLICATION
Anode material in lithium-ion batteries (natural and synthetic graphite).

MAIN SUPPLY GEOGRAPHY
- **Mining (natural)** China ~79%
- **Processing (battery-grade)** China ~94%

KEY PROCESSING CONSTRAINT
Purifying, shaping and coating graphite into battery-grade anode material at consistent quality.

TECHNOLOGY OR MARKET SHIFT
Silicon is increasingly blended into anodes; sodium-ion uses hard carbon. Graphite remains dominant, with supply highly concentrated.

Ni Co — Nickel & cobalt
The substitution story

EV APPLICATION
Cathode materials in NMC and NCA lithium-ion batteries.

MAIN SUPPLY GEOGRAPHY
- **Nickel mining** Indonesia ~60%
- **Nickel refining** Indonesia leads · n/a
- **Cobalt mining** DRC ~76%
- **Cobalt refining** China ~76%

KEY PROCESSING CONSTRAINT
Producing battery-grade nickel sulphate and refined cobalt at consistent quality.

TECHNOLOGY OR MARKET SHIFT
LFP growth is reducing nickel and cobalt use per kWh across the market; high-nickel chemistries remain important where energy density matters.

Cu — Copper
Electrification beyond the battery

EV APPLICATION
Motors, wiring, power electronics and charging infrastructure.

MAIN SUPPLY GEOGRAPHY
- **Mining** Chile ~23%
- **Refining** China ~47%

KEY PROCESSING CONSTRAINT
Mine supply rather than processing: long lead times and declining ore grades.

TECHNOLOGY OR MARKET SHIFT
Rising demand from EVs, grids, renewables and data centres is increasing competition for copper.

Nd — Rare earths
The magnet story

EV APPLICATION
Permanent magnets in traction motors (Nd, Pr; Dy, Tb for heat resistance).

MAIN SUPPLY GEOGRAPHY
- **Mining** China ~69%
- **Refining** China ~85%

KEY PROCESSING CONSTRAINT
Separating rare earths, producing metals and manufacturing high-performance magnets.

TECHNOLOGY OR MARKET SHIFT
Export controls since 2025 are spurring supply diversification and motor designs with less or no heavy rare earths.

Leading mining country

Leading refining or processing country

Mining: 2024 (USGS). Refining: latest IEA data (2024–25). Shares rounded.

Sources: IEA, *Global Critical Minerals Outlook 2026* and *Global EV Outlook 2026*; USGS, *Mineral Commodity Summaries 2025*; BOFIT, *Weekly Review* 32/2026. Note: Mining shares refer to 2024; refining and processing shares refer to 2024–2025 and are reported in BOFIT Weekly Review 32/2026. Shares are rounded, and map boundaries are indicative. Market developments reflect information available as of October 2026. Lithium price developments are as reported in the IEA's *Global Critical Minerals Outlook 2026*.

PACEPOINT ADVISORY

Li Lithium: the battery constant

Lithium is used in both NMC and LFP batteries, making demand less sensitive to shifts between these two leading chemistries than demand for nickel or cobalt. The commercial challenge is not simply to open mines, but to produce battery-grade carbonate or hydroxide reliably and at competitive cost. Prices and investment are cyclical, creating material risks for developers. After several years of decline, lithium prices more than doubled during 2025 and early 2026, according to the IEA. Sodium-ion batteries could reduce lithium demand in selected applications, although lithium-ion remains the dominant EV technology.

C Graphite: the overlooked battery mineral

Graphite is the dominant commercial anode material. Battery anodes use natural and synthetic graphite, both of which require specialized processing to meet demanding specifications. Purification, shaping, and coating are critical steps in the production of natural graphite, whereas synthetic graphite follows a different production route. Processing and anode-material manufacturing remain highly concentrated, creating supply-chain exposure beyond mine origin.

Ni Nickel and cobalt: the substitution story

High-nickel NMC batteries use nickel to achieve high energy density and include cobalt in the cathode formulation. LFP avoids both. NMC remains attractive where energy density and weight matter, although advances in LFP have narrowed the performance gap. Nickel and cobalt also serve substantial non-battery markets. Their EV demand is therefore particularly sensitive to battery-chemistry choices and broader market conditions. Producer-country policy matters too: the IEA now projects a 2035 cobalt supply gap of over 25%, up from just over 15% in its previous Outlook, reflecting the DRC's export quotas.

Cu Copper: electrification beyond the battery

Copper is used in EV motors, wiring, busbars, power systems and chargers, as well as the electricity grids that supply them. EV-related demand is only one part of a wider electrification story that includes renewable energy, transmission networks and data centers. Long mine lead times, declining grades in some deposits and large competing sources of demand make copper strategically important.

Nd Rare earths: the motor and magnet story

Rare earths are used in permanent-magnet traction motors. The central vulnerability is the concentration of separation, metalmaking, alloying and magnet manufacturing. Not all EV motors require rare-earth magnets, and manufacturers can choose alternative designs. This creates a different type of technology and supply chain risk than that posed by battery minerals.

The importance of these minerals is not simply a question of cost. Even when they account for a small share of a vehicle's price, a shortage of a critical input can disrupt production. Figure 9 illustrates this difference between cost exposure and supply-chain vulnerability.



FIGURE 9

Why critical minerals matter more for supply security than vehicle cost

Critical-mineral cost as a share of **battery cell cost**	~25%	Other materials, manufacturing, energy and other costs	IEA headline estimate
Critical-mineral cost as a share of **average EV price**	~3%	Everything else in the vehicle price	IEA headline estimate
Rare-earth cost as a share of **magnet cost**	~40%	Other materials and manufacturing costs	IEA headline estimate
Rare-earth cost as a share of **vehicle value**	<1%	Everything else in the vehicle value	IEA headline estimate

KEY TAKEAWAY

A low-cost input can still stop a high-value production line.

When China introduced rare-earth export controls in April 2025, some automakers had to reduce production or temporarily suspend operations (IEA, 2026). The risk is availability, not price.

Source: IEA, *Global Critical Minerals Outlook 2026*, including the launch press release. Note: All four values are IEA estimates, rounded as published. Each bar shows a share of its own base and is not comparable across rows. The April 2025 production impacts are as reported by the IEA.





SECTION FIVE

THE MINERAL MAP IS CHANGING

Battery chemistry, material efficiency, motor design and recycling are changing how much mineral supply is needed per vehicle.

05

SECTION 05

The mineral map is changing

EV growth does not translate into fixed rates of growth for every mineral. Battery chemistry, material efficiency, motor design and recycling are changing how much mineral supply is needed per vehicle.

Battery chemistry is changing demand.

LFP avoids nickel and cobalt, while sodium-ion may reduce lithium needs in some lower-cost or shorter-range applications.

Manufacturers are using materials more efficiently.

Battery-pack designs reduce inactive materials, silicon blends affect anode composition, and some motor designs avoid rare-earth magnets.

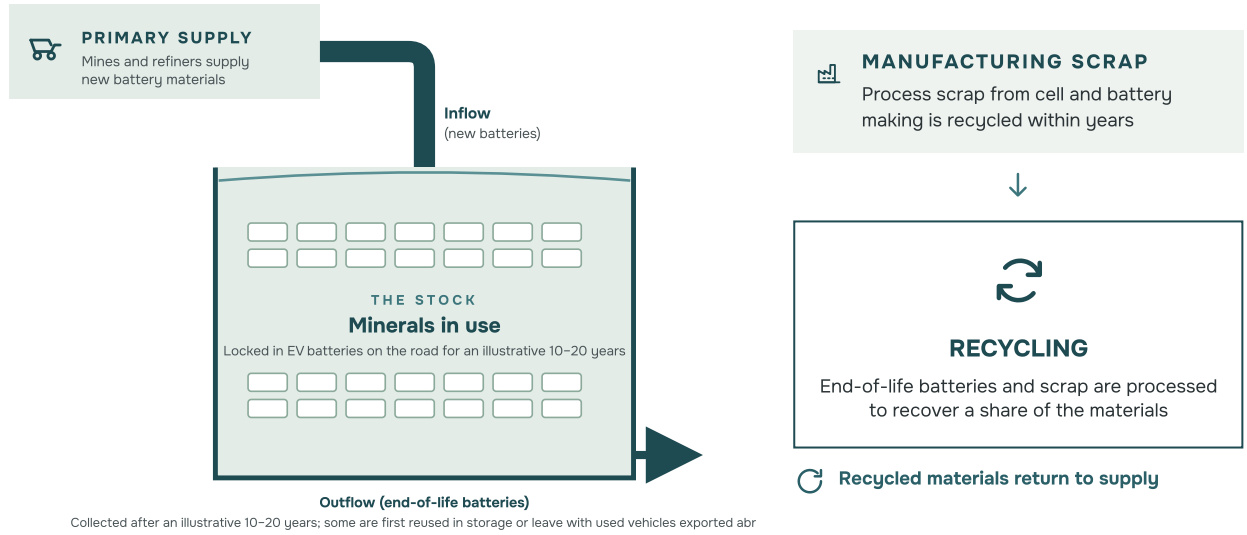
Recycling is becoming a larger source of supply.

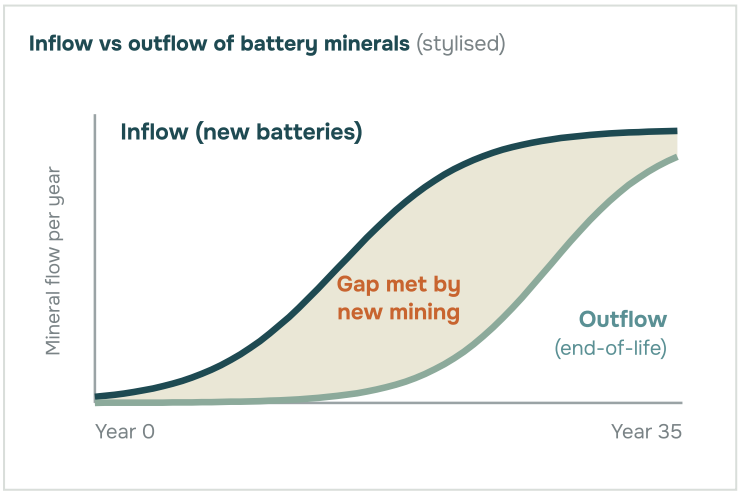
Manufacturing scrap is available now, while more end-of-life batteries will enter recycling systems as EV fleets mature.

Recycling faces a stock-and-flow challenge. Batteries sold today may remain in use for many years. During a period of rapid fleet growth, far more material enters service than becomes available from retired vehicles. Manufacturing scrap and retired batteries can contribute useful secondary supply, but new mining and processing will still be needed to meet additional demand.

FIGURE 10

Why battery recycling takes time to catch up with growing demand





~10% → ~20%

Average recycling rate across key energy minerals under today's policy settings, today versus 2040 (IEA). Not battery-specific.

Source: IEA, *Global Critical Minerals Outlook 2026*. Author's conceptual illustration of battery-material flows. Note: The 10–20-year battery lifetime is illustrative; actual retirement and recycling depend on battery use, durability, collection and reuse. The IEA estimates that recycling rates for key energy minerals could increase from around 10% today to close to 20% by 2040 under current policy settings. This is an average across all end uses and a scenario result, not an EV-battery recycling rate. The IEA does not provide a more precise definition of the recycling rate.

What EV growth means for mining

Rising EV demand supports investment in new mines and processing plants, but the outlook differs considerably by mineral. Under the IEA's Stated Policies Scenario, which reflects today's policy settings and is a projection rather than a forecast, lithium demand more than triples by 2040 and copper adds around 7 million tonnes, the largest increase in volume. Demand for nickel, graphite and rare earths grows more moderately in that scenario, while cobalt demand is increasingly moderated by the shift towards LFP batteries.

The quality of new supply matters as much as the quantity. Buyers, financiers and regulators increasingly scrutinize carbon intensity, water use, land impacts, labor conditions and traceability. The EU Battery Regulation is turning these expectations into obligations. The digital battery passport becomes mandatory from 18 February 2027 for EV batteries, industrial batteries above 2 kWh, and light means of transport (LMT) batteries; the EU registry supporting it became operational on 20 July 2026. Other obligations are not all fixed on that date: due diligence duties now apply from 18 August 2027 following a postponement, the EV carbon footprint declaration still awaits its delegated act, and minimum recycled content thresholds apply from August 2031.

Figure 11 illustrates how demand for six key minerals could change by 2040, highlighting the different growth trajectories and the role of battery technology in shaping future mineral requirements.



PACEPOINT ADVISORY

FIGURE 11

How demand for six key minerals could change by 2040

Mineral	Key demand drivers EVs and wider electrification	Key moderating factors Substitution, technology and recycling	Outlook to 2040 IEA, today's policy settings
Lithium	• EV demand across all mainstream lithium-ion chemistries (NMC and LFP). • Growing demand for stationary battery storage.	• Sodium-ion batteries in some lower-cost segments. • Smaller packs and efficiency gains reduce lithium per vehicle. • Increased recycling over time.	↑↑↑ **>3×** Strongest growth of the group
Graphite	• Used in almost all lithium-ion anodes today. • EV growth and larger vehicle fleets.	• Silicon-blended and other alternative anodes. • Hard carbon in sodium-ion batteries. • Increased recycling over time.	↑↑↑ **+50–90%** Driven by EVs; shared IEA range
Nickel	• High-nickel NMC and NCA batteries for longer range. • Stainless steel, the largest end use.	• LFP and manganese-rich chemistries (e.g. LMFP) reduce nickel per kWh. • Increased recycling over time.	↑↑↑ **+50–90%** Sensitive to battery chemistry mix
Copper	• Higher copper content in EVs (motors, wiring, power electronics). • Wider electrification: grids, renewables, buildings, data centres.	• Aluminium substitution where engineering allows. • Higher-voltage vehicle designs need thinner cables. • Increased recycling.	↑↑↑ **~+7 Mt** Largest rise in tonnes; mature market
Rare earths	• Permanent-magnet motors in many EVs. • Wind turbines, industrial motors and other uses.	• Magnet-free motor designs. • Lower heavy-rare-earth content in new magnets. • Recycling and material efficiency.	↑↑↑ **+50–90%** Sensitive to motor design
Cobalt	• NMC batteries. • Non-battery uses: superalloys, chemicals, other industry.	• Lower-cobalt and cobalt-free chemistries (e.g. LFP, high-manganese NMC). • Increased recycling over time.	↑↑↑ **Moderated** Growth slowed by LFP; no figure published

Source: IEA, *Global Critical Minerals Outlook 2026*, Outlook chapter, Stated Policies Scenario. Note: The figure illustrates projected changes in mineral demand to 2040 under the IEA's Stated Policies Scenario. In that scenario, lithium demand more than triples, while graphite, nickel and rare-earth demand increase by approximately 50–90%. Copper demand rises by around 7 million tonnes, a substantial increase in absolute terms. Cobalt demand growth has moderated amid the rapid rise of LFP batteries; the IEA does not provide a single percentage figure in the cited chapter. Demand covers all end uses, not EVs alone. Arrows are an illustrative summary of these reported ranges, not an IEA ranking, and the projections are scenario outcomes, not forecasts.

Pacepoint



SECTION SIX

BEYOND EXTRACTION

Where can mineral-rich economies capture value?

06

SECTION 06

Beyond extraction: where can mineral-rich economies capture value?

For mineral-rich emerging economies, EV supply chains create real opportunities, but the development proposition is often framed too simply. Producing lithium, nickel, cobalt, graphite or copper does not automatically create an advantage in battery-cell or vehicle manufacturing.

Each stage has different economics. Mining depends on geology and execution. Refining depends on reliable power, inputs and environmental controls. Battery materials require consistent quality and customer qualification. Cell manufacturing requires scale, technology and access to buyers.

> The useful policy question is not “How far can we move up the value chain?” but “Where can we build a commercially sustainable competitive position?”

Five considerations are particularly important.

	CONSIDERATION	KEY QUESTION
1	**Competitive resources**	Can minerals be produced competitively through price cycles, or can sufficient recycling feedstock be secured?
2	**Reliable infrastructure**	Are power, water, transport and logistics competitive and dependable?
3	**Skills and industrial capacity**	Can firms meet technical, operational and quality requirements?
4	**Access to customers**	Is there sufficient market scale, trade access and customer proximity?
5	**Investment environment**	Are fiscal, regulatory and trade arrangements predictable over long investment periods?



FIGURE 12

What matters for competitiveness at different stages of the EV supply chain

	1. Competitive resources Is the deposit large, high-grade and low-cost enough? For recycling: is there enough feedstock?	2. Reliable infrastructure Are power, water, transport and logistics competitive and dependable?	3. Skills and industrial capacity Can firms meet technical, operational and quality requirements?	4. Access to customers Is there sufficient market scale, trade access and customer proximity?	5. Conditions for investment Are fiscal, regulatory and trade arrangements predictable over long investment periods?
Mining	Critical	Medium	Lower	Lower	Critical
Refining & processing	Medium	Critical	Medium	Lower	Critical
Battery materials	Lower	Critical	Critical	Medium	Critical
Cells & components	Lower	Medium	Critical	Critical	Critical
Vehicle assembly	Lower	Lower	Critical	Critical	Medium
Recycling	Critical	Medium	Medium	Medium	Medium

Lower importance · Medium importance · Critical importance

⚠ **Further downstream is not automatically better.**

Source: Author's illustrative assessment. Note: Ratings indicate the relative importance of different commercial and operating conditions across EV supply-chain activities. Resource ratings reflect the importance of local mineral endowment or feedstock availability, rather than access to competitively priced material inputs. All ratings are indicative and will vary by country, mineral and business model.

For mineral producers in Africa, Latin America and parts of Asia, the binding constraints are usually power, customer qualification and offtake, not the absence of a local cell plant. Export bans and local-processing mandates should be judged against those constraints. Zimbabwe suspended exports of raw minerals and lithium concentrates in February 2026, later eased the measure under quotas, and still plans a full concentrate ban from January 2027. Where the commercial case is weak, such measures risk transferring economic benefits between market participants, discouraging investment or supporting processing facilities that cannot compete without continued protection.

Moving further downstream is only one route to greater value. Countries can also improve mining productivity, develop local suppliers, strengthen engineering services and increase the domestic economic contribution of existing operations. These opportunities can create more sustainable jobs and economic returns than subsidizing downstream facilities that lack competitive foundations.



Four countries, four strategies to test

Countries are pursuing different approaches to developing critical-mineral and battery industries, reflecting their resource endowments, industrial capabilities and policy priorities. The four examples below should be viewed as strategies being tested rather than proven models. Much of the evidence still comes from government and company announcements, and facilities reported as operational have not necessarily demonstrated sustained, commercially qualified output.

Each example rests on a different hypothesis. In Indonesia, mineral resources can support domestic processing where energy, technology and market access are competitive. In Morocco, established automotive and chemical industries can attract battery investment even without large battery-metal deposits. In the DRC and Zambia, regional cooperation can create opportunities where infrastructure, trade arrangements and industrial capabilities are sufficiently developed. Chile illustrates how an established mineral industry and greater state participation can support upstream development, while attracting downstream manufacturing remains a challenge.

Each also faces a clear commercial test. In Indonesia, energy costs, nickel price cycles and the expense of meeting environmental requirements could erode processing competitiveness. In Morocco, battery-materials production at Jorf Lasfar and the Kenitra cell gigafactory must achieve customer qualification and secure long-term offtake. In the DRC and Zambia, reliable power, transport infrastructure and workable cross-border fiscal arrangements remain critical to commercial viability. In Chile, the terms of state participation and the fiscal regime will influence whether the strategy can attract competitive downstream investment. Where these tests are not met, announcements alone will not translate into competitiveness in industry.



FIGURE 13

Four approaches to building critical-mineral and battery industries: strategies and commercial tests

Indonesia

Nickel processing expansion

STATED STRATEGY

Banned nickel-ore exports (2020) and attracted large, mostly Chinese-backed investment in smelting and battery-grade intermediates.

EVIDENCE OF PROGRESS

Operational

Large-scale nickel smelters and battery-grade intermediates (e.g. HPAL) in operation

In progress

Further refining and precursor projects under construction

Proposed

Additional cell and battery projects announced

KEY CONSTRAINTS

Exposure to nickel price cycles, coal-based power, environmental and social impacts, and reliance on imported technology.

LESSON TO TEST

Resource scale combined with a clear policy can attract processing investment, but environmental and market risks remain significant.

Morocco

Industrial base and trade access

STATED STRATEGY

Built a competitive automotive base, leveraged phosphate resources and trade agreements with the EU and US to attract battery-materials and cell investment.

EVIDENCE OF PROGRESS

Operational

COBCO reported starting NMC precursor and cathode-material production at Jorf Lasfar in June 2025

In progress

Gotion LFP cell gigafactory at Kenitra: first 10 GWh line due to start October 2026

Proposed

LFP cathode capacity awaiting regional demand; further projects announced

KEY CONSTRAINTS

Limited domestic lithium, nickel and graphite; need to scale local suppliers and workforce; competition from other locations.

LESSON TO TEST

An industrial base, logistics and trade access can attract battery investment without large battery-metal deposits.

DRC & Zambia

Regional battery-materials ambition

STATED STRATEGY

Partnering on cobalt (DRC) and copper (Zambia) to develop a regional battery-precursor value chain.

EVIDENCE OF PROGRESS

Not yet

No precursor production yet; the DRC exports cobalt hydroxide, an intermediate

In progress

Musompo zone (DRC): works officially launched March 2025; made a priority project in 2026; progress reported to have slowed

Proposed

Joint DRC–Zambia precursor plant planned; location still under discussion

KEY CONSTRAINTS

Power and transport gaps, regulatory uncertainty, need for regional coordination, and reliance on foreign investment and technology.

LESSON TO TEST

Pooling resources across borders is a credible proposition, but delivery depends on infrastructure, policy clarity and coordinated implementation.

Chile

Lithium resources and partnership

STATED STRATEGY

World's largest lithium reserves; the 2023 National Lithium Strategy increases state participation and offers preferential lithium supply for local value-added projects.

EVIDENCE OF PROGRESS

Operational

Battery-grade lithium carbonate and hydroxide production

In progress

Codelco–SQM partnership agreed, extending the state's role in lithium

Withdrawn

BYD and Tsingshan cathode and LFP plants withdrawn in 2025 as lithium prices fell

KEY CONSTRAINTS

Water and environmental concerns, community and permitting challenges, and limited progress on domestic battery manufacturing.

LESSON TO TEST

Resource strength and price incentives can secure upstream investment, but have not yet anchored downstream manufacturing.

Operational · In progress · Proposed · Withdrawn · Not yet

Status as of October 2026

Sources: Author's synthesis from IEA, *Global Critical Minerals Outlook 2025* and *2026*; USGS, *Mineral Commodity Summaries 2025*; company and government announcements reported by electrive (June 2025 and May 2025), TimesLIVE, reporting Reuters (June 2025), The Rio Times (October 2026), Bankable (April 2025), Actualité.cd (March 2025) and Energy News Network (August 2026). Illustrative, not exhaustive. Note: Project status is based on public reporting and company or government statements available as of October 2026, rather than independent verification. "Operational" indicates that production has reportedly started, not necessarily that commercial output has been confirmed. "In progress" includes agreed, launched or scheduled projects and does not necessarily indicate physical construction. The lessons are the author's interpretation.

PACEPOINT ADVISORY



AN ANALOGY FROM COCOA

Côte d’Ivoire and Ghana produce close to half the world’s cocoa.

Yet much of the value associated with finished chocolate is captured through manufacturing, branding and retail in other markets. Both countries have expanded domestic cocoa processing, showing that greater local value addition is possible. But competing in finished chocolate requires different capabilities, including manufacturing expertise, distribution and consumer access.

The lesson for battery minerals is similar: producing the raw material can provide an advantage, but each additional stage must be commercially competitive in its own right.

For Africa, Latin America and parts of Asia, regional industrial ecosystems may offer stronger opportunities than individual countries attempting to build every stage of the supply chain. Minerals can be mined in one country, processed in another and used in manufacturing in a third, provided reliable infrastructure, trade arrangements and common standards connect these activities.

Recycling offers another opportunity, drawing on vehicle fleets, collection networks and industrial capabilities rather than domestic mineral deposits.

> **Mineral endowment creates an opportunity. Competitiveness determines how much of it can be captured.**



SECTION SEVEN

SO WHAT?

Implications by audience.

07

SECTION 07

So what? Implications by audience

Governments of mineral-producing countries

1. Assess the commercial viability of domestic processing before introducing export restrictions or local processing requirements, including energy costs, infrastructure, customer demand, and the potential impact on existing mining investment.
2. Prioritize shared power, transport, skills and trade systems that benefit multiple industries.
3. Pursue regional value chains where they improve scale and access to customers.
4. Strengthen responsible production, traceability and predictable regulation.

Investors and development finance institutions

1. Evaluate project viability across price cycles and plausible technology-substitution scenarios.
2. Target genuine processing and infrastructure constraints backed by credible demand.
3. Use blended finance and public-private partnerships selectively to address demonstrable risks and shared infrastructure gaps.
4. Distinguish announced projects from financed, operational and customer-qualified capacity.

Automakers and battery manufacturers

1. Map exposure across refining, materials and components, not just mine origin.
2. Maintain flexibility in battery chemistry and motor design where technically and commercially feasible.
3. Diversify qualified suppliers and build partnerships for recycling and traceability.
4. Prepare for the EU battery passport from 18 February 2027 (EVs, industrial batteries above 2 kWh, and LMT batteries) and battery due diligence from 18 August 2027, while tracking the delegated acts still pending, including the carbon footprint methodology.



CONCLUSION

From mineral endowment to competitive capability

The EV transition is creating new mineral demand, but the opportunities are neither uniform nor guaranteed. Battery chemistry, processing capacity, manufacturing capabilities and trade policy will continue to shape which minerals matter and where supply chains develop.

For mineral-rich economies, the opportunity is not simply to move further downstream. It is to capture more economic value wherever they can build competitive capabilities, whether through productive mining, local suppliers, processing, manufacturing or regional industrial partnerships. Reliable infrastructure, technical capability and access to markets will determine which opportunities are commercially sustainable.

THE BOTTOM LINE

Having the minerals creates an opportunity. Building the capabilities determines whether that opportunity becomes lasting economic value.

PACEPOINT ADVISORY

REFERENCES

Sources

INTERNATIONAL ORGANIZATIONS AND OFFICIAL STATISTICS

International Energy Agency (2026). *Global EV Outlook 2026*, chapter on electric vehicle batteries. Paris: IEA.

International Energy Agency (2026). *Global Critical Minerals Outlook 2026*. Paris: IEA (released 16 July 2026). Includes the Outlook chapter and the accompanying press release, "Supply concentration, export restrictions and declining investment put critical mineral security at risk".

International Energy Agency (2025). *Global Critical Minerals Outlook 2025*. Paris: IEA.

International Energy Agency (2021; chart updated 2022). *The Role of Critical Minerals in Clean Energy Transitions*; chart "Minerals used in electric cars compared to conventional cars". Paris: IEA.

U.S. Geological Survey (2025). *Mineral Commodity Summaries 2025*. Reston, VA: USGS.

LEGISLATION

Regulation (EU) 2023/1542 of the European Parliament and of the Council concerning batteries and waste batteries, as amended by Regulation (EU) 2025/1561; European Commission, "Digital Product Passport: batteries" (accessed October 2026).

Regulation (EU) 2024/1252 of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials (Critical Raw Materials Act).

POLICY ANALYSIS AND RESEARCH

Bank of Finland Institute for Emerging Economies (BOFIT) (2026). "China retains dominance of critical raw material production". *BOFIT Weekly Review* 32/2026, 7 August 2026.

King & Spalding (2026). "Critical Minerals Snapshot: Key Takeaways from 2026 So Far". June 2026.

Pillsbury Winthrop Shaw Pittman (2025). "China Suspends Export Controls on Certain Critical Minerals-Related Items". November 2025.

The Conference Board (2026). "Policy Backgrounder: The US Critical Minerals Ministerial and Industrial Policy". February 2026.

Wang, S., Cook, P. and Alimento, R. (2026). *The Critical Minerals Picture Book*. Breakthrough Institute.

NEWS REPORTING

Actualité.cd (2025). "RDC : début des travaux pour une zone industrielle dédiée à la transformation locale des minerais". 28 March 2025.

Al Jazeera (2026). "Zimbabwe imposes ban on exports of all raw minerals and lithium concentrate". 25 February 2026.

Bankable (2025). "DR Congo: Development of Musompo Special Economic Zone begins". 1 April 2025.

electrive (2025). "BYD & Tsingshan pull out of Chile lithium projects". 8 May 2025.

electrive (2025). "COBCO starts EV battery material production in Morocco". 26 June 2025.

Energy News Network (2026). "Africa battery value chain moves up a step as DRC approves Musompo precursor zone". 18 August 2026.

pv magazine (2026). "Morocco hosts Africa's first battery manufacturing plant". 3 August 2026.

The Rio Times (2026). "Kenitra Battery Gigafactory Plans First Cell Line in October". 9 October 2026.

Times LIVE, reporting Reuters (2025). "Sino-Moroccan COBCO begins producing EV battery materials". 26 June 2025.

Yahoo Finance (2026). "China rare earth export pause nears expiry amid persistent supply concentration". 27 April 2026.

Notes

This report draws on publicly available data, research and policy announcements, including publications from the International Energy Agency (IEA), the US Geological Survey (USGS) and other sources listed in the references.

Market shares are rounded and should be treated as indicative. Mining shares generally refer to 2024, based on USGS data, while refining and processing shares refer to 2024–2025, drawing on IEA data reported by BOFIT.

Policy developments and industrial projects are described based on publicly available information as of October 2026. Announced investments, partnerships and planned facilities should not necessarily be interpreted as operational or commercially established.

Several figures are conceptual illustrations or draw on the author's analysis to explain supply-chain relationships and investment considerations. Demand projections reflect IEA scenarios rather than predictions of future outcomes. The report distinguishes between reported data, illustrative frameworks and the author's interpretation where relevant.

Pacepoint

PACEPOINT ADVISORY

From Mine to Motor

An illustrated briefing · October 2026 · Kenneth Ene