KONTEXT

ANALYSIS

Beyond Critical Raw Materials: Scaling Next-Generation Batteries in Europe

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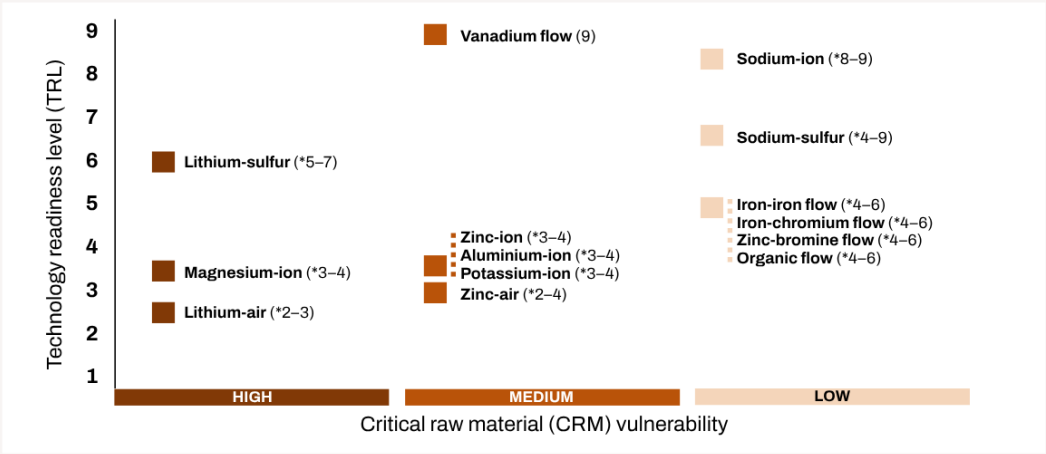
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OVERVIEW

Scaling Next-Generation Batteries in Europe

TECHNOLOGIES

Next-generation batteries exist, but still need to scale



BARRIERS

Most pressing barriers from lab to market

- Gaps between research and industry
- **Missing early-stage capital**
- **Uncertain demand**
- Shortage of skilled workers
- Under-developed supply chains
- Slow substitution of critical raw materials
- **Missing and unclear rules**

ENABLERS

Three policy proposals to remove the most pressing barriers

Targeted capital

- **Co-investment:** The state invests alongside private investors on the same terms, within a fixed budget per round
- **Loan guarantees:** The state guarantees up to 80 percent of bank loans within fixed budget caps
- *In both cases: Private investors provide at least 50 percent of the capital*

Lead markets

- **Contracts for Difference:** The state pays the cost gap to conventional batteries, producers repay any surplus, under a multi-year contract.
- **Public procurement:** Public authorities buy storage through binding contracts and score bids on price and on non-price criteria

Clear rules

Ground Rules for Scaling

These rules give producers and investors a clear direction, incentives and make progress measurable

- **Storage targets:** Binding targets for deployment and production up to 2040, in annual steps
- **Harmonised standards:** One EU set of norms on safety, performance, durability and grid connection
- **Monitoring and governance:** Yearly tracking of deployment, production and CRM data, national strategies

Shared eligibility criteria

Critical raw material vulnerability score from 1 (low) to 3 (high) and priority for ‘Made in the EU’ production.

Note: * = TRL range
Source: KONTEXT Institute (2026): Beyond Critical Raw Materials: Scaling Next-Generation Batteries in Europe.

1. Introduction

Renewable energy can free Europe from its dependence on oil and gas, but only if the power it generates is available when it is needed. Renewable electricity is cheaper and cleaner than fossil energy and it is produced domestically instead of being imported. It also makes it possible to electrify transport, heating and industry. Yet some of this potential remains unused, because renewable power is often generated at a different time than it is consumed.

Storage closes this gap between generation and consumption. If the grid is the backbone of the energy system, storage is its muscle. It absorbs electricity and releases it on demand, so power is used when and where it is most efficient. With enough storage, locally generated electricity can be consumed locally, grids become more stable and gas plants no longer have to step in at peak demand. This reduces Europe‘s exposure to fossil price shocks. Backing the right storage technologies can also give Europe a competitive advantage.

Batteries will play a central role in this storage system. They are the fastest-growing storage technology and their deployment has risen exponentially in recent years. In 2025 alone, the EU installed a record 27.1 GWh of new battery storage and its battery fleet is now ten times larger than in 2021. In the coming years, batteries will be key to unlocking the full potential of renewables. For this reason, this analysis focuses on batteries.

In their current form, most batteries depend heavily on critical raw materials. In other storage types, such as pumped hydro or hydrogen, these materials are needed only for single components like generators or electrolysers. In batteries, they are built into the core technology itself. As deployment grows, so does demand for lithium, cobalt, nickel, graphite and other critical raw materials. Europe imports most of these materials from a small number of countries and supply disruptions threaten its security of supply. Diversifying suppliers, recycling and using resources more efficiently are important. So far, however, they cannot keep pace with rising demand.

A European battery industry can turn this dependency into an industrial opportunity and the window to build it is open now. Today, lithium-ion battery production is concentrated in a small number of manufacturers, most of them based in China. The market for the next generation of batteries, which need significantly fewer critical raw materials, is not yet dominated by any single country or company. By scaling up storage now, Europe can develop and produce these technologies and establish them on the world market. This strengthens Europe‘s self-determination and turns a dependency into a competitive advantage.

Existing EU policy does not yet target this next generation of batteries. The EU has many instruments for the battery industry, but they mostly reward where a battery is made and hardly consider what it is made of. Technologies that use fewer critical raw materials (CRMs), or low-CRM technologies, benefit only as a side effect. This leaves a gap for instruments that actively support them.

This analysis asks how the EU can close this gap and scale up batteries that need fewer critical raw materials. It addresses three questions:

1. Which battery technologies that use fewer critical raw materials already exist?
2. Which barriers currently keep this industry from scaling up in the EU?
3. Which concrete policies can remove the most pressing barriers?

This report addresses these three questions. Chapter 3 introduces the low-CRM battery technologies and their critical raw material supply chains. Chapter 4 draws on industry interviews to identify seven barriers that keep EU-based battery producers from scaling up. Chapter 5 presents three policy proposals: risk capital for the early stage, lead markets and a regulatory framework that brings this next generation of storage to scale. Chapter 6 applies these proposals to Austria and shows what can be implemented nationally and where EU action is needed.

2. Methodology

This analysis combines three methods: desk research, industry interviews and expert workshops. The technology overview (Chapter 3) is mainly based on literature research, the analysis of barriers (Chapter 4) on interviews and literature and the policy proposals (Chapters 5 and 6) on expert workshops, complemented by research on existing policies and conclusions drawn from both.

An extensive literature review provides the basis for all chapters, above all the technology overview. It covers scientific studies, industry reports, market data and EU policy documents on battery technologies and critical raw materials. On this basis, the analysis rates the critical raw material (CRM) vulnerability of each technology, using import reliance, supplier concentration and recycling rates from SCRREEN3 data. Two interviews with experts from the Austrian Institute of Technology (AIT) and TU Wien complement the overview. They helped to assess the state of research and to place each technology in context. In this report, the term 'next-generation batteries' refers to batteries that use as few CRMs as possible. They therefore go beyond market dominant lithium-ion technologies, including less CRM-intensive lithium iron phosphate (LFP), since lithium is itself a critical raw material. This does not rule lithium out altogether. It can still be used in niche applications where its properties offer clear advantages. For mass-market applications, however, the aim is to develop competitive alternatives to lithium-ion that keep CRM use as low as possible.

Interviews with eight battery producers from five EU countries show which barriers companies face in practice. Most of them are start-ups and scale-ups. Together, they cover a broad range of next-generation batteries at different technology readiness levels:

- Sodium-ion: Altris (Sweden), Bihar Batteries (Spain), Salzstrom (Austria)
- Vanadium redox flow: Cellcube Energy Storage (Austria), Visblue (Denmark)
- Organic redox flow: Jena Batteries (Germany), Ecolyte (Austria)
- Lithium-sulfur: Theion (Germany)

The interviews confirmed and expanded the barriers identified in the literature. Above all, they added practical insight from companies that face these barriers every day. Their input mainly shaped the analysis of barriers in Chapter 4.

Three expert workshops shaped the policy proposals, together with further desk research. Two workshops took place in Brussels with stakeholders from think tanks, NGOs and industry. The first tested the barriers from the interviews against the experts' assessment. The second discussed policy measures for these three barriers and assessed how effective and feasible they would be at EU level. The third workshop took place in Vienna. It explored how the proposed measures could be implemented in Austria (Chapter 6).

All policy proposals were assessed against four criteria:

1. **Higher production:** Does the measure increase the actual volume of low-CRM batteries that are produced and sold?
2. **Closing the cost gap:** Does it close the cost gap that keeps low-CRM chemistries from competing with lithium-ion batteries?
3. **Focus on low-CRM products:** Does it target low-CRM chemistries specifically, rather than batteries in general?
4. **Legal feasibility:** Can it realistically be implemented under existing EU competences and state aid rules?

The three proposals address different barriers, so they meet these criteria to different degrees. Together, they are designed to cover all four.

3. Background: Energy Storage Technologies and the Role of Next-Generation Batteries

3.1. How Energy Can Be Stored

The energy transition is the central pillar of decarbonisation and the key to freeing Europe from volatile and expensive dependencies of oil, gas and coal. This needs two inseparable developments: scaling up renewable energy generation and phasing out fossil fuels through electrification. Electrification is a precondition for the energy transition. Renewable energy generates electricity, which heat pumps, electric vehicles and industrial processes can use directly. Electricity thus becomes the main energy carrier of the ecological transformation. The energy transition, thus, secures long-term independence, energy sovereignty and price security.

Unlike fossil energy, renewable electricity cannot be produced on demand. While oil, gas and coal are extracted, transported, stored and burned on demand, new renewable electricity is *supply*-driven. Generation occurs when and where meteorological conditions of water, sun and wind permit. Storage technologies bridge this mismatch by decoupling generation from consumption, over periods from minutes to entire seasons. *Table 1* gives an overview of the storage technologies available today. They are grouped by the form the energy takes while it is stored: an electric or magnetic field, a chemical bond, movement or elevation, heat, or a fuel molecule (Tomše et al., 2024, Mahnoor et al., 2025, Xun et al., 2025).

Storage technologies differ in how long they hold energy and how much they depend on critical raw materials (CRMs). Electrical storage, such as supercapacitors, releases energy within milliseconds to minutes and is mainly used for grid stabilisation. Electrochemical storage, mainly batteries, covers seconds to several hours. It is the backbone of daily balancing, home and utility-scale storage and e-mobility. Mechanical storage, above all pumped hydro, operates over hours to months. Thermal storage converts electricity into heat or cold. Chemical storage converts it into fuels such as hydrogen, ammonia or methane. Both are suited to long-duration and seasonal use.

CRM dependency is mostly concentrated in batteries. Electrical storage needs almost no CRMs. Mechanical and chemical storage need them only for single components such as generators or electrolysers. In batteries, CRMs are part of the core technology. Most market-leading chemistries depend on at least one CRM in the cell and several depend on more than one. The range includes lithium, cobalt, nickel, graphite, vanadium, manganese, aluminium and magnesium.

All storage types are needed, but they play different roles. Thermal and chemical storage turn electricity into heat or fuel, which cannot be converted back into electricity without large losses. Their main role is to decarbonise uses that cannot be electrified directly, such as industrial process heat or parts of aviation and heavy transport. Batteries store electricity for later use as electricity. Their demand is also set to rise most sharply, while most of the value they create is captured outside the EU (see Chapter 3.3). If current technologies are simply scaled up, today's CRM dependencies grow with them. For these reasons, this report focuses on batteries and on how they can be produced with fewer CRMs.

Energy Storage Systems Compared

	Usual storage capacity	Technologies (most common)	Primary function	Critical raw materials used
Electrical electricity stored directly	**Short** milliseconds – minutes	• Supercapacitors • Superconducting coils (SMES)	• Grid stabilisation • Frequency regulation	Depending on technology: niobium (mostly), rare earth metals (for high-performance technologies)
Electro-chemical electricity ↔ chemical energy	**Short – Medium** seconds – hours or days	• Batteries • Flow batteries	• Daily/weekly balance • Home & utility storage • E-mobility	Depending on technology: lithium, cobalt, nickel, graphite, vanadium, manganese, aluminium, magnesium
Mechanical electricity ↔ motion or height	**Short – Medium** hours – months	• Pumped hydro • Compressed air • Flywheels • Liquid air • Gravity	• Daily balance • Peak demand balancing (peak shaving) • Grid stabilisation	Rare earth metals for generators & engines
Thermal electricity → heat or 'cold'	**Medium – Long** hours – months	• Sensible & latent heat storage • Thermochemical storage	• Seasonal heating • Industrial heat	
Chemical electricity → fuel	**Long** weeks – months	• Hydrogen • Ammonia • Methane	• Industrial decarbonisation • Fuel or feedstock • Seasonal storage	Depending on technology: platinum group metals (sometimes) & nickel (mostly) for electrolysers

Source: KONTEXT (2026) based on expert interviews, Tomše et al. (2024), Mahnoor et al. (2025), Xun et al. (2025).

Table 1

3.2. Batteries and Their Dependence on Critical Raw Materials

Battery storage is growing faster than other power technologies. Pumped hydro still accounts for the largest share of stored energy, both globally and in the EU (Joint Research Center, 2026). In 2025 alone, however, 108 GW of new stationary battery capacity was installed worldwide, 40 percent more than in the previous year. Around 80 percent of it was utility-scale, the rest behind-the-meter. Installed capacity is now eleven times higher than in 2021 (IEA, 2026a). The EU also set a new record in 2025, with 27.1 GWh of new battery storage, 45 percent more than in 2024. Its battery fleet grew tenfold between 2021 and 2025, from 7.8 GWh to 77.3 GWh (SolarPower Europe, 2026).

This growth comes with a structural vulnerability, because many battery technologies depend on CRMs with fragile supply chains. The EU considers a raw material critical when it is important to the economy and faces a high supply risk, usually because extraction or processing is concentrated in a few countries. It lists 34 critical raw materials, 17 of which are also labelled 'strategic'. Demand for these strategic materials is expected to rise sharply, and they are central to the green and digital transition and to defence (European Court of Auditors, 2026). A large share of their supply comes from a single country, China. This creates geopolitical dependencies, exposes key sectors to supply disruptions and weakens Europe's competitiveness. Supply risks differ strongly between the CRMs used in batteries, as the box below shows.

Nearly all CRMs used in batteries carry a significant supply risk *(Table 2).* This leads to severe security issues for the ongoing electrification in Europe. It makes Europe geopolitically and economically dependent on countries that process or mine these materials. The risk rating for each material combines three indicators: import reliance (the share of non-EU extraction or processing capacity relative to total EU use), supplier concentration (the share of total supply accounted for by a single non-EU country) and recycling rate (European Court of Auditors, 2026, SCRREEN3, 2026). Together, they allow a rough classification into high, medium and low risk. It is important to note that even a low rating means some risk remains. The SCRREEN3 data used here gives an aggregate view per material, although risk can differ between the specific forms of a material.

Critical raw materials in battery technologies

Lithium, cobalt, nickel, graphite, aluminium, magnesium and manganese are classified as both critical and strategic raw materials. Vanadium is 'only' classified as critical. Its supply risk is high, but its demand is not expected to grow as strongly.

Supply chains. *For most of these materials, mining is somewhat diversified, but processing into battery-grade material is not, which shows that diversification of mining alone does little to reduce dependency. China accounts for roughly two thirds of global lithium refining and around 80 percent of cobalt sulphate production. Vanadium and graphite production is also concentrated in China, but the EU sources both from more diverse suppliers. Manganese comes mainly from Gabon (about half of EU supply) and South Africa (about a third). Magnesium is the most exposed material, with China covering 92 percent of EU demand, leaving little room for diversification. Recycling, however, is possible, with a recycling rate of 13 percent in the EU.*

Recycling. *EU recycling rates are highest for aluminium (32%), cobalt (22%), nickel (16%) and magnesium (13%). For lithium (0%) and vanadium (1%), recycling is technically feasible but barely used.*

Mining conditions. *Cobalt mining in the Democratic Republic of the Congo is linked to hazardous working conditions and child labour. Lithium and aluminium raise mainly environmental concerns such as water and extensive land use. Magnesium production in China relies on the coal-fired Pidgeon process, one of the most carbon-intensive ways to produce a metal and a significant source of local air pollution.*

Critical Raw Materials for Batteries Face Supply Chain Risks

	Overall supply risk	Import reliance	EU supplier concentration	EU recycling rate
Lithium	High	High	High	0%
Cobalt	Medium	High	Medium	22%
Nickel	Medium	Medium	Medium	16%
Vanadium	High	High	Medium	1%
Aluminium	Low	Medium	Low	32%
Magnesium	High	High	High	13%
Manganese	High	High	Medium	9%
Graphite	High	High	Medium	3%



Note: Import reliance: high if extraction or processing reliance exceeds 80%, medium if 50–80%, low if below 50% of total use. The higher of the two stages applies; EU supplier concentration: share of the largest supplier to the EU at either stage, high above 50%, medium 20–50%, low below 20%. The higher of the two stages applies; EU recycling rate: according to European Court of Auditors Report; Overall supply risk: estimate based on import reliance, concentration and EU recycling rate.

Source: KONTEXT (2026) based on SCRREEN (2026), European Court of Auditors Report (2026)

Table 2

3.3. Next-Generation Batteries: Maturity, Vulnerability and Use Cases

Lithium-ion batteries still dominate the market, but the battery industry is moving towards chemistries with fewer CRMs. Lithium-ion batteries (LIB) owe this dominance to their high energy density, low weight and successful scaling, which drove prices down sharply (Sciatti et al., 2026). But even within this first generation of batteries, the industry is shifting towards chemistries that need fewer critical raw materials: Lithium iron phosphate (LFP), the cobalt- and nickel-free LIB variant, accounted for around 90 percent of new stationary storage deployments worldwide in 2025 (IEA, 2026a). Five years earlier, its share was well below 50 percent. LFP has largely replaced nickel-based chemistries such as NMC (nickel-manganese-cobalt) and NCA (nickel-cobalt-aluminium), as well as lead-acid batteries. To date, however, next-generation batteries are still underrepresented: sodium-ion, the most advanced contender, has a cell manufacturing capacity of just over 1 percent of lithium-ion capacity, with announced projects for 2030 amounting to only around 7 percent of committed lithium-ion capacity (IEA, 2026b). Besides switching chemistries, some R&D efforts aim to reduce critical raw materials within Li-ion batteries themselves, for example through organic cathodes that replace critical metals (Chen et al., 2024). This work is still at the laboratory stage. Lithium-sulfur and lithium-air batteries are being developed most likely for aviation, such as drones and electric aircraft, where low weight matters most (Dörfler et al., 2021). Both are still at the research stage *(see Table 3).*

Next-generation batteries are still a niche, but their market is opening up new opportunities for Europe's industrial power and independence. Today, lithium-ion battery production is concentrated in a small number of manufacturers, most of them based in China. This leaves Europe dependent on a handful of external suppliers for a technology which is the keystone to unlock the full potential of renewable energy. The market for the next generation of low-CRM battery chemistries, however, is not yet dominated by any single country or company. If Europe invests in these technologies now, it has a real chance to become one of the leading producers and suppliers of this next generation of batteries. This secures a fast and efficient energy transition, ultimately leading to energy sovereignty, lower energy prices and independence from fossil fuels. In this report, the term 'next-generation batteries' refers to battery technologies beyond Li-ion that need fewer or no CRMs. *Table 3* gives an overview of the main technologies (Stephan et al., 2023).

Beyond Lithium-Ion: Types of Next-Generation Batteries

Category	Most relevant technologies	TRL	Critical raw materials used	CRM vulnerability
Metal-ion batteries (Me-ion) — same technical principle as Li-ion, different metals	Sodium-ion (SIB)	8–9	Manganese: sometimes; Aluminium: mostly	low
	Sodium-ion, saltwater (SIB Salt)	2–3	Not assessable (very low TRL)	–
	Magnesium-ion (MIB)	3–4	Vanadium: sometimes; Manganese: sometimes; Magnesium: always	high
	Zinc-ion (ZIB)	3–4	Manganese: mostly; Vanadium: sometimes	medium
	Aluminium-ion (AIB)	3–4	Aluminium: always; Graphite: mostly	
	Potassium-ion (KIB)	3–4	Graphite & Manganese: sometimes	
	Calcium-ion (CIB)	2–3	Not assessable (very low TRL)	–
Metal-sulfur batteries (Me-S) — sulfur reacts chemically with the metal	Lithium-sulfur (Li-S)	5–7	Lithium: always; Graphite: sometimes	
	Sodium-sulfur (Na-S)	4–9	Aluminium: always	
Metal-air batteries (Me-air) — metal reacts with oxygen	Zinc-air (Zn-air)	2–4	Manganese: mostly; Cobalt & PGM: sometimes	
	Lithium-air (Li-air)	2–3	Lithium: always; Graphite & PGM: mostly	
Redox flow batteries (RFB) — energy stored in pumped liquid electrolytes, not in fixed electrodes	Vanadium (VRFB)	9	Vanadium: always	
	Iron-iron (IFB)	4–6	None	
	Iron-chromium (ICFB)	4–6	None	
	Zinc-bromine (ZBB)	4–6	None	
	Organic (ORFB)	4–6	None	

Note: TRL = technology readiness level, PGM = platinum group metals.

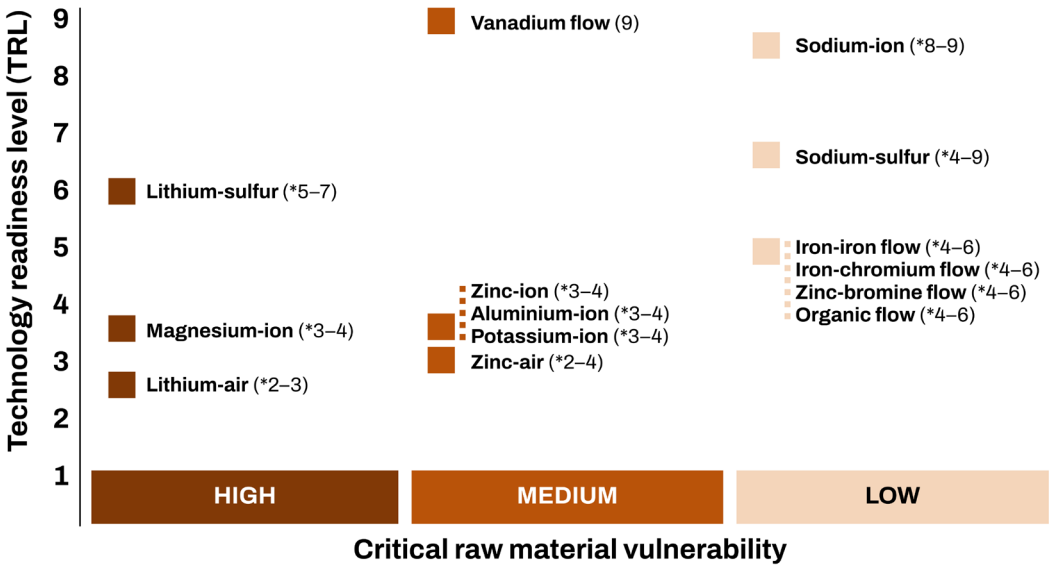
Source: KONTEXT (2026) based on expert interviews, Stephan et al. (2023), SCRREEN (2026).

Table 3

Next-generation batteries fall into four main types, and each carries its CRM risk in a different place. *Metal-ion* batteries work like Li-ion but replace lithium with a more abundant ion such as sodium, magnesium, zinc, aluminium or calcium. Sodium-ion cells, for example, can use aluminium foil on both electrodes and need no copper (Alcántara et al., 2023). *Metal-sulfur* batteries use a sulfur cathode that needs no CRMs. Their dependency lies in the anode metal, such as lithium in lithium-sulfur, or in components such as the ceramic electrolyte of sodium-sulfur (Guo & Liu, 2019). *Metal-air* batteries carry their CRM risk not in the metal anode but in the air-cathode catalyst, which ranges from manganese to higher-performance platinum-group metals (Barman et al., 2025). *Redox-flow* batteries store energy in a liquid electrolyte based on vanadium, iron, chromium or organic compounds, for example. Their CRM dependency is therefore a property of the whole chemical system (Fischer et al., 2022).

Two factors show which technologies are most promising for Europe: technological maturity and CRM vulnerability. The technology readiness level (TRL) shows how close a technology is to large-scale deployment, from early lab research (TRL 1–3) and validated prototypes (TRL 4–6) to commercial systems (TRL 7–9). Some, like sodium-ion and vanadium flow batteries, are already mature enough to scale today. Others, such as magnesium-ion, lithium-air or organic flow batteries, still need breakthroughs in materials, cost or durability. TRL can vary between suppliers, since their formulations differ. CRM vulnerability depends on which CRMs a technology uses and how risky their supply chains are *(Table 2)*. This allows a rough rating of high, medium or low. Sodium-ion, for example, relies mainly on aluminium, a low-risk material and uses high-risk manganese only in some variants. Its overall vulnerability is therefore low. Lithium-sulfur always depends on high-risk lithium and sometimes on graphite, so its vulnerability is high. *Graph 1* maps both factors for all technologies in *Table 3*.

Resilient Next-Generation Batteries Exist, but Still Need to Scale



Note: * = TRL range
Source: KONTEXT (2026) based on expert interviews, Stephan et al. (2023), SCRREEN (2026).

Graph 1

Different promising next-generation battery technologies already exist. Sodium-ion is one of Europe's clearest near-term opportunities. It is highly mature (TRL 8–9) and has a low vulnerability to critical raw materials. Several flow batteries, such as iron-iron, iron-chromium, zinc-bromine and organic flow batteries, are just as low in vulnerability but less mature (TRL 4–6). Vanadium flow batteries are a special case. They are highly mature, ready to scale and particularly suited to stationary and industrial storage. Their use of vanadium makes them moderately vulnerable. However, vanadium is largely produced as a co-product of steelmaking and the electrolyte does not degrade and can be reused over several life cycles (Blume et al., 2022; Heigl et al., 2025). According to the expert interviews conducted for this report, this leaves room to diversify supply more than for other CRMs. These are the technologies Europe could develop, scale and bring to the world market if it invests now. Lithium-sulfur, magnesium-ion and lithium-air batteries, by contrast, combine low maturity with high vulnerability and currently hold the least potential for broad applications.

Each technology needs to be used where it fits best. Suitability depends on energy density, weight, production and material costs, cycle life and reliability. These factors decide whether a battery suits mobile or stationary use, on-grid or off-grid operation and small home storage or large utility applications (International Energy Agency (IEA), 2026; Sciatti et al., 2026; Zubi et al., 2018). No single technology fits every use case.

Li-ion is the most versatile technology today, but its advantage shrinks as storage durations grow. Its high energy density makes it the default for electric vehicles. In stationary storage, it is optimised for durations of up to four hours (Evelina Stoikou, 2024). But as the share of renewables in the grid rises, storage needs a shift towards long durations of six hours or more. On these durations, Li-ion becomes less attractive, because every additional hour of storage adds cost almost linearly (Evelina Stoikou, 2024).

The most promising alternative depends on the use case. For electric mobility and short-duration storage, *sodium-ion* is the most promising alternative. Its energy density is lower than that of *Lithium-ion,* so it suits cost-sensitive, shorter-range vehicles and stationary applications, where weight matters less (IRENA, 2025; Oliver Krätzig, 2023). *Sodium-sulfur* batteries, could provide grid services such as peak shaving, though their high operating temperature restricts them to large stationary installations (Nikiforidis et al., 2019). For stationary storage of medium to long duration, *flow batteries* are the most likely alternative. Their lower energy density matters little in stationary use. Power and capacity scale independently, so additional storage hours mainly require larger tanks and the cost per hour falls as duration increases (Evelina Stoikou, 2024). Most importantly, flow systems use a non-flammable, water-based electrolyte, which is an advantage wherever fire regulations are strict. It also allows taller tanks to be built and stacking up storage capacity for large sites.

Among flow batteries, several alternatives exist. Vanadium flow batteries can scale now, because they are already commercially mature (TRL 9). They depend on a single critical raw material, whereas NMC cathodes (nickel-manganese-cobalt), alone depend on four: lithium, nickel, cobalt and manganese (Cheng et al., 2025). Their electrolyte also does not degrade with cycling (Schreiber & Harrer, 2011). Iron-based, zinc-bromine and organic flow batteries can follow as they mature. They avoid CRMs altogether but are still at TRL 4–6. Organic flow batteries are the most resource-efficient option. However, their molecules degrade over repeated cycling, so they need more maintenance. This is offset by their repairability. Components of organic flow systems can be replaced, whereas Li-ion cells have a shorter and fixed lifespan and must be replaced as a whole.

A European battery industry can turn this dependency into an industrial opportunity, but the industry needs adequate technological clarity. Next-generation batteries are still a niche, but their market presence is growing. Flow batteries remain a small share of global energy storage but are expanding rapidly. Yet China's *Rongke Power* brought the world's first gigawatt-hour-scale vanadium flow battery plant online in 2025 (LDES Council, 2026). Sodium-ion accounted for less than one percent of global battery production for electric vehicles and stationary storage in 2024–2025. Its announced manufacturing capacity is set to grow from about 70 GWh per year today to over 400 GWh per year by 2030 (Ed Crooks, 2025; IRENA, 2025). This could correspond to about 5 to 10 percent of the rechargeable battery market in 2030 (Arvidsson et al., 2026). To realise this potential, next-generation batteries must overcome barriers at every stage of deployment. Chapter 4 examines the most pressing ones.

4. Barriers to Scaling Up Next-Generation Batteries

Many promising energy technologies fail on the way from the lab to the market. This chapter asks whether this pattern also applies to next-generation batteries and where in the implementation chain the barriers lie. It first looks at lessons from other clean-tech industries. It then presents seven barrier categories and explains which of them this report focuses on.

4.1. Lessons Learned from Other Clean-Tech Industries

Europe's solar industry shows how quickly an industrial lead can be lost. In the mid-2000s, generous government payments for feeding solar electricity into the grid (‚feed-in tariffs') created such strong domestic demand for solar installations that Germany also became a world leader in producing solar panels. Within just a few years, however, almost all of these companies had gone out of business. Heavily subsidised Chinese competitors undercut them before they could grow big enough to compete on cost (McWilliams et al., 2024).

Money alone does not explain this collapse, because policy design and timing played a key role. Germany's Renewable Energy Law (EEG – Erneuerbaren Energie Gesetz), in force since 2000, obliged grid operators to connect every solar installation and pay the guaranteed feed-in tariff for 20 years (Umweltbundesamt, 2023). From 2015, this guarantee was replaced by competitive auctions, earlier than the industry could cope with. Producers lost the stable revenue that had made long-term investment possible, right when they needed it most to withstand cheap Chinese imports (McWilliams et al., 2024). The EEG surcharge on electricity prices also made energy-intensive solar production in Germany more expensive. China took the opposite path. From 2015, its solar factories could buy cheap coal power directly from power plants at negotiated prices ('direct power trading') (Grau et al., 2012). Financing followed the same pattern. During the 2008–2012 financial crisis, European banks cut back lending to capital-intensive manufacturers. At the same time, Chinese state banks such as the China Development Bank expanded their lending, so Chinese producers kept scaling up and pushing prices down (Grau et al., 2012; Mercom, 2011).

EU support schemes can also reinforce existing structures. The *Important Projects of Common European Interest* (IPCEI) channel strategic funding toward innovation and infrastructure projects. They tend to favour large, well-connected firms and wealthier member states, which leaves smaller players and poorer regions behind (McWilliams et al., 2024, *see Chapter 5 on policy options).* This matters because established players are not necessarily the best innovators. In European solar PV, firms with the largest stock of patents innovated less under competitive pressure, possibly because they were locked into older technologies. Firms with smaller knowledge stocks innovated more (Andres, 2024). Funding that flows mainly to incumbents may therefore reinforce existing technological paths rather than support the newcomers best placed to develop alternatives.

Rules meant to protect European production can also fall short. The Net-Zero Industry Act requires sustainability and resilience criteria in renewable energy auctions, but Member States may choose not to apply them where they would raise bid prices by more than 15 percent. This limits how far such rules can offset the price gap: Chinese onshore turbines sold outside China were almost 30 percent cheaper than European and US ones in 2019–2024 (Janipour, 2024; Monaghan, 2025).

4.2. Seven Barriers from Lab to Market

Next-generation batteries face a well-known problem, the 'valley of death' between a proven concept and large-scale production. Many of these technologies are mature, or close to it, but have not yet reached competitive industrial production. Research identifies two such gaps for Europe's next-generation battery industry. The first lies between basic research and a working prototype, the second between the prototype and gigafactory-scale production (European Commission. Joint Research Centre., 2024).

In practice, barriers appear at many more points along the chain, from raw material sourcing to pilot-scale validation and market entry and they differ in weight. Based on the literature and eight industry interviews, this report groups them into seven categories:

1. Gaps between research and industry
2. Missing early-stage capital
3. Uncertain demand
4. Shortage of skilled workers
5. Underdeveloped supply chain
6. Slow substitution of critical raw materials
7. Missing and unclear rules

Gaps between Research and Industry

Knowledge from the lab does not automatically turn into manufacturing processes. Much of the practical know-how needed for this step is firm specific, built up through hands-on experience and is rarely written down or shared between organisations (Howells, 1996). Equipment manufacturers are often involved too late, so processes that work in the lab fail at pilot scale (Vilkman et al., 2024). The fragmented battery value chain widens this gap. Scaling up requires universities, start-ups, equipment manufacturers, suppliers, investors and end users to work together. Between them, shared facilities, pooled expertise and clear pathways are often missing, which adds delay and risk at every step (Attar, 2026).

Missing Early-Stage Capital

Scaling from a prototype to industrial production requires more capital than most early-stage investors are willing to commit. In the 'valley of death', a technology is too advanced for public research grants but not yet proven enough for private investors. The stage is CAPEX-heavy. Pilot lines, first commercial plants and gigafactories all need large upfront investment, while it is still uncertain whether the technology will succeed in the market. Even where early profits appear, margins stay thin, which makes it hard to attract investors (Vilkman et al., 2024). The bankruptcy of Northvolt, a Li-ion producer, shows how quickly this capital gap can threaten even a well-funded, high-profile company (Tagliapietra & Trasl, 2024).

Pilot infrastructure is a special case of this financing gap. Testing whether a technology can be manufactured at scale requires intermediate-scale facilities. No single start-up company usually has enough incentive to fund them alone, since competitors could also benefit. Firms also prefer smaller, private lines over shared ones, partly because they worry about losing intellectual property. As a result, shared pilot lines are undersupplied (Vilkman et al., 2024). Open-access facilities such as Fraunhofer FFB in Germany and the CIDETEC pilot line in Spain show how this barrier can be overcome.

Uncertain Demand

Even a mature technology can fail if there is not yet enough reliable demand. Instruments such as demand-side obligations and green public procurement already create predictable demand in sectors like heavy industry, but they have not yet been extended to battery storage (Foglia & Pernot, 2025). Without long-term purchase agreements, lenders cannot rely on future revenue, which makes it harder to finance production (Vilkman et al., 2024). Li-ion is also a moving target. Its cost and performance keep improving, so alternatives such as sodium-ion cannot rely on scale alone to close the gap (Yao et al., 2025).

Shortage of Skilled Workers

Scaling up battery production requires skills that Europe does not yet have at scale. Beyond academic expertise, industrial production needs quality control, automation and process operation, which are mainly vocational skills (Batteries Europe, 2020; Vilkman et al., 2024). So far, the gap is manageable, since most jobs in the sector are still research-based and Europe has a large academic workforce. As production grows, it is expected to become a serious constraint. According to Fraunhofer ISI, up to 1.5 million workers in the EU battery value chain will need training or upskilling by 2030 and 4–5 million by 2050 (Thielmann et al., 2024). Firms already rate this shortage as serious as high energy costs (McCaffrey & Poitiers, 2024).

Underdeveloped Supply Chains

Even chemistries which avoid CRMs depend on specialized equipment, materials and recycling infrastructure that Europe has not yet built. Specialized manufacturing equipment comes from only a few global producers, which can cause delays regardless of raw material availability. Where cells are assembled in the EU on non-EU machinery, European producers also lack the know-how to operate it. A fully European supply chain, from raw material to finished cell remains the exception, even for Lithium-ion-batteries. Battery cells and other key components in particular are still largely produced outside Europe and low-CRM chemistries do not automatically escape this pattern: to date, nearly all sodium-ion manufacturing capacity is in China (IEA, 2026c). Repair and maintenance capacity also lags behind. For next-generation technologies, which are often ready to deploy but not yet commercialised, these gaps leave partners and customers unsure about their reliability.

Slow Substitution of Critical Raw Materials

Replacing CRMs in batteries also faces barriers beyond the technology itself. Substitution is not a clear priority in EU policy. The Net-Zero Industry Act, for instance, does not address the substitution of critical raw materials (European Court of Auditors, 2026). Existing next-generation options are not yet mature enough to cover every application. The expert interviews conducted for this analysis also pointed out that CRMs are arguably underpriced, since their market price rarely reflects their carbon footprint or supply risk, which weakens the incentive to replace them. Research on replacing CRMs often runs in parallel with large-scale production, so firms are developing the replacement for a chemistry they are already producing. Policy should therefore support low-CRM technologies and continued research on substitution at the same time.

Missing and Unclear Rules

A regulatory framework for new battery technologies is largely missing while existing rules favour established lithium-ion batteries. Clear deployment targets for storage are rare, also within electrification and renewables targets, which makes monitoring and accountability difficult. Basic technical standards are missing too, such as chemistry-specific safety certifications, cell-format standards and clear legal definitions for new or less mature technologies. Li-ion technology, meanwhile, benefits from decades of lock-in, with an established supply chain, certification bodies, recycling plants, long-term contracts and infrastructure. Any alternative has to build these from scratch. Path-dependence research shows how early advantages compound through scale, learning and network effects, even where better alternatives exist (Arthur, 1989).

Storage also often lacks a legal category of its own. EU policy recognises its dual role as both consumer and generator, yet several Member States still lack a legal definition of storage. In some, storage still pays network charges twice, once when charging and once when feeding electricity back into the grid. This puts storage at a disadvantage against generation facilities (Contini et al., 2026). Permitting timelines for new factories and recycling plants are also hard to predict (Vilkman et al., 2024). This uncertainty holds back investment and demand and leaves manufacturers without a clear signal for planning production.

This report focuses on three of the seven barriers: missing early-stage capital, uncertain demand and missing or unclear rules. Industry interviews identified them as the most pressing and the first expert workshop discussed them further. A 2024 survey by the European Investment Bank and the European Patent Office supports this choice. Lack of finance was among the two most-cited obstacles for clean-tech innovators, particularly for micro and small companies (43 percent, against 12 percent of large companies). Medium and large firms named consistent EU regulation as the main way to foster commercialisation (EIB, 2024b). The report also notes that uncertain future demand raises financing costs and the eight industry interviews repeatedly named demand as an equally important constraint. The other barriers remain real obstacles. A shortage of skilled workers, for example, was cited as often as financing in the EIB survey. Capital, demand and clear rules, however, offer the clearest leverage points for policy to help Europe's next-generation battery industry grow. Chapter 5 sets out how.

5. Enablers: Capital, Demand and Clear Rules

This chapter turns from barriers to solutions. For each of the three barriers in focus, it develops an enabler, a set of policies that can remove the barrier. Section 5.1 first gives a short overview of the EU instruments that the enablers build on. Each enabler then follows the same structure. It looks at what the EU already does, draws on best practices from individual countries and ends with a concrete policy proposal. Each proposal is assessed against the four criteria from Chapter 2. It should increase the production of low-CRM batteries, close their cost gap with Li-ion, target low-CRM technologies specifically and be legally feasible under EU law.

5.1. Existing EU Regulations for the Battery Industry

The EU already has a wide range of instruments for the battery industry. They work on three levels. Strategies set political goals but are not binding. Laws set binding rules. Funding instruments turn both into money for individual projects. This section describes the instruments that matter for the enablers and for the case study in Chapter 6.

Strategy

The **Clean Industrial Deal** (February 2025) sets the Commission's overall clean-industrial roadmap. The **Battery Booster Strategy** (December 2025) adds battery-specific priorities in six pillars. One of them, 'Supporting 'made in EU' offtakes (...)', aims for more EU-made batteries in electric vehicles and storage systems (European Commission, 2025a, 2025b). As Commission Communication, the strategy is not binding. Its EU-origin goals would only become binding through the Industrial Accelerator Act (IAA, see below).

Binding rules

Four sets of binding rules shape the battery market. All of them treat battery chemistries alike, including Li-ion and do not favour lower CRM dependency. The **Net-Zero Industry Act** (NZIA, in force since June 2024) lists batteries as a core net-zero technology. It sets a 2030 goal for domestic manufacturing. Strategic battery projects get faster permitting through a single contact authority ('one-stop-shop'). The NZIA also requires non-price criteria, such as resilience, in renewable energy auctions, public procurement and electric vehicle subsidy schemes (see Enabler 2). The **Critical Raw Materials Act** (CRMA, in force since May 2024) sets 2030 benchmarks for EU extraction (10 %), processing (40 %) and recycling (25 %) of strategic raw materials. Strategic projects get faster permitting and easier access to finance. The **Battery Regulation** (in force since August 2023) sets rules for batteries on the EU market, including carbon footprint, durability, recycling and, from February 2027, a digital battery passport. Recycled-content quotas and due-diligence duties apply only to cobalt, lithium, nickel and, for due diligence, natural graphite. Batteries without these materials are exempt from both duties (see Enabler 2). The **Clean Industrial State Aid Framework** (CISAF, in force since June 2025) defines what state aid Member States may grant to clean-tech manufacturers. It allows investment aid, such as grants, loans and guarantees for building factories. It excludes aid per unit produced, as used in the US Inflation Reduction Act. CISAF is formally a Commission Communication, but it binds the Commission when it reviews state aid. Whether a Member State uses it is a national choice. The **Industrial Accelerator Act** (IAA) is currently still a regulation proposal (March 2026). It would set minimum EU-content requirements for public procurement and public funding. It would also attach conditions to foreign investments above €100 million from countries that hold over 40 percent of global manufacturing capacity in a sector. The aim is to strengthen EU clean-tech production. The IAA is still early in the legislative procedure. Its foreign direct investment rules are criticised as conflicting with the EU's open-investment principles, so the final shape remains uncertain (García Bercero et al., 2026)

Funding

EU funding for batteries mainly reaches large projects. The **Battery Booster Facility** (a Commission Decision under the EU Innovation Fund) is the funding arm of the Battery Booster Strategy. It offers up to €1.5 billion in interest-free loans

given directly by the EU, to manufacturers in the ramp-up phase with a capacity of at least 10 GWh. Small and new producers, which might produce next-generation batteries are unlikely to qualify. **IPCEI Batteries** (Important Project of Common European Interest) combines national and EU state aid in two funding waves. Like IPCEI in general, it has so far mainly benefited large firms (Poitiers & Weil, 2022).

Three findings matter for the enablers that follow. First, none of these instruments target low-CRM batteries. Where they benefit, it is a side effect, as with the exemptions under the Battery Regulation. Second, key instruments are new, non-binding or not yet adopted: the Battery Booster Strategy is not binding, the IAA is still a proposal and CISAF, the NZIA's non-price criteria and the Battery Booster Facility have only applied since 2025 or 2026, so how they work in practice remains to be seen. Third, funding mainly reaches large projects. Small and young companies, including most of the low-CRM producers interviewed for this report, are largely left out.

5.2. Enabler 1: De-Risking Capital Investments

What is a risk-capital investment?

Next-generation battery manufacturers need capital before they can prove that their technology works at scale. This is called risk capital: money committed before there is proven demand, stable revenue or a track record (building on the 'Valley of Death' literature, e.g. Gaddy et al., 2016). Private investors firstly are less willing to commit to this kind of risk and secondly charge a premium for this uncertainty. This raises the cost of capital and can make sound projects impossible to finance. Policy can respond in several ways. It can share risk with private investors, replace private capital with public capital, reduce the capital each company needs, or secure future revenue. These tools act on the cost and risk of capital. Lead-market instruments (Enabler 2) act on demand for the product.

- **Loan guarantees:** The state covers part of the default risk on a specific loan. The lender is protected and is willing to offer better terms (e.g. lower interest rates).
- **Blended finance (first-loss capital):** Public money is invested alongside private money but absorbs losses first. Private investors are protected until that public share is used up.
- **Public co-investment funds:** The state invests directly alongside private investors, sharing risk and signalling confidence that attracts further private capital.
- **Direct public lending (e. g. venture debt):** A public bank such as the EIB lends directly to the company and carries the default risk itself.
- **Cap-and-floor schemes:** A corridor is set for a project's revenue. If revenue falls below the floor, the state pays the difference. If it rises above the cap, the project pays the extra back.
- **Investment tax credits:** A fixed share of the investment is returned through tax credits, regardless of later success.
- **Production tax credits:** A fixed payment per unit produced, once production runs. This does not lower the investment cost itself.
- **Open-access pilot infrastructure:** The state funds a shared facility, so companies do not each have to build their own. This lowers the capital any single company has to risk.

A) What Exists in the EU

None of the instruments from Chapter 5.1 targets a specific chemistry. Their relevance for low-CRM batteries only becomes clear from their eligibility rules and design details. This section looks at three areas: the legal basis for sharing capital risk, actual funding for batteries and strategic project status under the CRMA.

CISAF provides the legal basis for sharing capital risk. It allows Member States to support manufacturing projects for net-zero technologies, including batteries, in two main ways. The first is investment aid for building plants. Depending on region and company size, it can cover 15 to 35 percent of costs, up to €150–350 million per project. The second is a dedicated de-risking section. It allows equity, loans and guarantees through funds or special-purpose vehicles that hold portfolios of eligible projects. The Commission describes this aid as meant "to de-risk private investment into portfolios of eligible projects, in order to mobilise additional private funding" (European Commission, 2025d). Guarantees and loans are capped and a guarantee can cover only part of a loan. CISAF is a menu of pre-approved aid designs, not an obligation. It provides no money itself and does not favour any chemistry. Each Member State decides whether, how generously and for which companies to use it.

At EU level, battery manufacturing already receives public finance through several instruments. Besides the Battery Booster Facility and IPCEI (see Chapter 5.1), the clearest example is the EIB–Commission battery partnership. It has three parts: a guarantee that lets the EIB lend more venture debt, Innovation Fund grants for electric vehicle battery-cell manufacturing and EIB investment along the value chain, excluding mining and extraction (EIB, 2024a). Unlike CISAF, it is one finite EU pool, so it can run out once fully committed. Eligibility does not depend on chemistry. The Battery Booster Facility and IPCEI Batteries, by contrast, mainly reach large projects (Poitiers & Weil, 2022).

Strategic project status under the CRMA eases access to finance. Projects receive financing advice and introductions to investors through the Critical Raw Materials Board. They also become eligible for support from the Cohesion Fund and the European Development Fund. This is a soft instrument. It commits no funds and takes no risk. The substitution category, for projects that replace CRMs, is the only pathway clearly relevant for low-CRM technologies. Very few of the first selected projects fall into it.

Instruments that de-risk private capital are still rare. CISAF is new. The national schemes approved so far, for example in Germany and Slovakia, rely on grants, tax relief and loan support, but not on guarantees to funds with private co-investors. Battery-specific EU guarantees, such as the EIB–Commission partnership, are small and do not distinguish between chemistries (European Sting, 2026; Insight EU Monitoring, 2026).

Two gaps remain. First, no instrument makes eligibility depend on CRM content. A low-CRM manufacturer competes for CISAF aid, EIB venture debt or strategic project status on the same terms as any Li-ion incumbent. Second, small producers in the ramp-up phase lack reliable support. In this phase, yields and quality are still being optimised, so unit costs are highest. CISAF excludes aid per unit produced and the Battery Booster Facility targets large manufacturers of at least 10 GWh of capacity and suitable technology for electric vehicles (European Commission, 2026c). These two gaps are the starting point for the proposal in Section C.

B) Best Practices

Several European countries already use these instruments successfully. Their examples show how public support can share risk or reduce capital needs while still attracting private investment.

Germany's Fraunhofer FFB shows how public pilot infrastructure reduces the risk capital each company needs. The research facility in Münster is funded with close to €1 billion from federal and state budgets. It is publicly owned and open to companies of all sizes. Firms can test and scale up cell production for several technologies, such as lithium-ion, sodium-ion or solid-state, without building their own pilot line. Binding contracts, need-to-know access and the physical and temporal separation of clients protect confidentiality, so even competitors can use the same facility (Fraunhofer FFB, 2026). Spain's CIDETEC applies the same model on a smaller scale. Its open-access pilot and testing line in the Basque Country cost more than €6 million and is available for cell development and certification (Cidetec, 2021).

BasqueVolt shows how public money can attract private capital instead of replacing it. The Basque start-up develops solid-state batteries and aims for industrial production by 2027. The Basque Government granted it €19.4 million, covering half of the planned investment, with private partners contributing the rest (elDiario, 2022). In 2025, Ekarpen, Stellum and the Spanish state co-investment fund CDTI Innvierte provided almost €10 million in further financing to accelerate industrialisation (EFE, 2025).

The UK's cap-and-floor scheme shows how a guaranteed revenue corridor can attract investors. It sets a minimum and a maximum for a project's annual revenue. The floor covers the project's debt payments and the cap reflects the return investors expect on their own capital (Energy UK, 2026). If revenue falls below the floor, a charge on consumer bills makes up the difference. Between floor and cap, the project keeps all revenue and carries normal business risk. Above the cap, most of the extra profit goes back to consumers. Interconnector projects under the scheme have already returned several million pounds to UK consumers (National Grid, 2022) and Ofgem now applies it to long-duration storage. However, the scheme covers storage *operation,* not battery manufacturing.

France's C3IV shows how a national investment tax credit can build on EU state aid rules. Introduced in 2024 and extended to 2028, it covers batteries, wind, solar and heat pumps, including key components and the CRMs used in them (C3IV). Eligibility is linked directly to the technology lists in CISAF and the CRMA. The credit is deducted from corporate tax. If it exceeds the tax owed, the rest is paid out in cash, so even companies without profits receive liquidity. Rates range from 15 percent for large firms to 55 percent for small firms in regional aid zones, capped at €150–350 million per project. Any company can apply. Approval depends on supply-chain resilience, contribution to the target sector, R&D in France and local jobs and skills (DGFiP, with ADEME and DGE). The scheme is chemistry-neutral, but sodium-ion production is explicitly eligible. Tiamat, a spin-off of the French research centre CNRS, is building France's first sodium-ion gigafactory near Amiens (€500 million, 700 MWh from 2026). It is on the same list as Li-ion producers such as ACC and Verkor. By 2026, C3IV had supported 73 projects with €3.6 billion in credits and triggered around €22 billion in investment. This is close to the government's original estimate of €23 billion. No independent evaluation exists yet.

C) Policy Proposal 1: How to Target Capital for Next-Generation Batteries

Existing instruments leave two gaps. They do not target low-CRM batteries and they mainly finance large projects, so smaller new producers are left out (see Section A). A targeted instrument needs two building blocks to close these gaps. Eligibility criteria define which projects receive support. A financing instrument, either direct co-investment or loan guarantees, then shares the risk with private capital providers. This section sets out what both building blocks should contain and which design choices remain open.

How to Target Capital for Next-Generation Batteries

01 Setting the eligibility criteria

Critical raw material (CRM) vulnerability

Score 3 (high) to 1 (low), based on which CRMs a chemistry uses and how exposed their supply chains are. The rating method is transparent and reviewed regularly. Applicants document their chemistry with battery passport data. In the long term, a maximum score of 2 applies.

Priority for 'Made in the EU' production

WTO-compliant, so non-EU suppliers cannot be fully excluded. Dependence on any single non-EU country could be capped, as in the Net-Zero Industry Act (NZIA). 'Made in the EU' should be defined uniformly, for example by value added or share of components.

Baseline requirement

Private investors provide at least 50 percent of the total capital needed.



02 Designing the instrument

Direct co-investment (equity)

The state invests directly in the company, alongside a private investor and on the same terms.

- **Terms:** Public and private investors invest on the same terms.
- **Selection:** A qualified party (private co-investor or state) checks technology, finances and market before investing (due diligence).
- **Budget cap:** A fixed budget per multi-year round.
- **Concentration:** Investments are capped per company and spread across company sizes and technologies.
- **Exit and reinvestment:** The public stake is sold after a set period and the returns are reinvested.

Portfolio loan guarantee

The state guarantees part of a bank loan and covers part of the loss if the company defaults.

- **Terms:** Up to 80 percent of the loan is guaranteed, never the full amount. Bank and state share losses in the agreed proportion. Borrowers pay a risk-based fee.
- **Selection:** The bank checks the borrower's creditworthiness.
- **Budget caps:** Caps on new guaranteed volume per year and on total payouts per portfolio.
- **Concentration:** Guarantees are capped per borrower.
- **Form:** Portfolio guarantees for smaller loans, individual guarantees for larger plants.
- **Use of funds:** Investment in pilot lines, production capacity and ramp-up.
- **Time frame:** Set period, matched to the loan term and ramp-up.

03 Implementing the instrument

- **EU framework:** Criteria & rating for the vulnerability score and 'Made in the EU', minimum design standards, monitoring.
- **National implementation:** Funds & guarantees via national promotional institutions, budget caps.

Note: Step 2 sets out the design choices that have to be defined for the instrument to work, grouped by category.
Source: KONTEXT Institute (2026): Beyond Critical Raw Materials: Scaling Next-Generation Batteries in Europe.

The proposal lowers the financial risk of building production capacity for next-generation batteries. It combines two instruments that serve different needs. Direct co-investment brings public money into a company's equity, but only alongside private investors, mostly for pilot lines, production capacity and ramp-up. Loan guarantees help companies raise bank debt.

Uniform eligibility criteria direct the capital to the right producers. The first criterion is low CRM vulnerability. Each chemistry is rated from 1 (low) to 3 (high), based on the rating in Chapter 3. The method is published and reviewed regularly, because supply risks and technologies change. Applicants document their chemistry with data they already provide for the digital battery passport. Producers are rated by this score and lower vulnerabilities are favoured. Once more next-generation producers exist in the EU, the maximum eligible score can be lowered to 2. Batteries with very vulnerable supply chains can then be excluded. The second criterion favours production in Europe as far as legally possible. To comply with WTO rules, non-EU suppliers are not fully excluded. Instead, dependence on any single non-EU country is capped, as in the NZIA. 'Made in the EU' also needs one clear definition, based on the measure that best captures the European share of a product, such as value added or share of components. A basic requirement applies on top. Private investors must provide at least 50 percent of a company's total capital need. The state therefore never invests alone or carries all the risk and companies only qualify once private investors have committed.

The design rules protect public money and attract private capital. In co-investments, public and private investors invest on the same terms, so public money does not subsidise private returns. A qualified party checks each company before money is invested. A fixed budget per multi-year round keeps public spending predictable. Caps per company and a spread across company sizes and technologies limit losses if one company fails. The public stake is sold after a set period and the returns are reinvested in new companies. In guarantees, the state covers up to 80 percent of a loan and bank and state share losses in the agreed proportion. The bank keeps part of the risk and therefore checks the borrower carefully, so only economically viable companies receive loans. Borrowers pay a fee that covers part of the expected losses, so the scheme partly finances itself, while borrowers gain access to credit at lower interest. Portfolio guarantees serve smaller loans, single guarantees serve larger plants and an annual cap limits the total volume. Actual payouts per portfolio are capped, so the public spending stays in limits.

Implementation depends mainly on the EU, because state aid and financial rules are largely set at EU level. The Commission sets the eligibility criteria, the rating method, the rules on production in Europe and minimum design standards, such as the maximum public share in co-investments and the coverage range for guarantees. This prevents Member States from outbidding each other. The Commission also monitors how funds are used per technology, linked to the monitoring proposed in Enabler 3. Member States set up the funds and guarantee schemes under CISAF, usually through national promotional banks and decide on the budget. They can also channel funds through the Member State compartment of InvestEU to use existing EIB/EIF structures. CISAF already allows these instruments, so no new state aid rules are needed today. However, CISAF expires at the end of 2030, while pilot lines and gigafactories need financing beyond that date. The framework should therefore be extended or carried over into a successor framework.

The proposal meets three of the four criteria fully. It closes the cost gap only in part, which Enabler 2 addresses.

5.3. Enabler 2: Building Lead Markets

What is a lead market?

Low-CRM batteries need reliable buyers and a viable price before they can compete. A lead market is a market that adopts an innovation early and successfully, from which it then spreads to other markets (Beise, 2004). It emerges when local demand helps an innovation succeed early. Where these conditions do not arise on their own, policy can create a lead market by shaping demand (Agora Industry, 2024). This matters most for innovations that are more efficient, secure or sustainable but cannot yet scale on their own. Common policies are:

- **Demand-side obligations (quotas):** A minimum share of purchases or sales must meet a set standard. Demand is guaranteed, whatever the price.
- **Green public procurement:** Public buyers favour a technology or standard in their own contracts. Public procurement makes up 15 percent of EU GDP (Beucler & Makaroff, 2025).
- **Contracts for Difference (CfD):** The state guarantees a fixed price, paying the gap when market prices are lower and recovering it when they are higher. This reduces producers' price risk.
- **Buyer alliances with counterparty-risk insurance:** Several small buyers join in one large contract that is insured against default. Investors can then rely on this demand.
- **Auctions:** Companies compete for public support and the lowest bid wins. Specific criteria can be favoured or required.
- **Product labelling or certification schemes:** A product's origin or CRM footprint is made visible to buyers, without any purchase obligation.

A) What Exists in the EU

None of the instruments from Section 5.1 was designed to create demand for low-CRM batteries. Some of them, however, attach conditions to demand or give low-CRM batteries an incidental advantage.

Three instruments attach conditions to demand, but none of them names a chemistry. Since December 2025, the NZIA requires Member States to apply non-price criteria to at least 30 percent of their renewable energy auction volume, or 6 GW per year. One of eight optional criteria is 'energy system integration'. It allows auctioneers to reward generation coupled with battery storage (European Commission, 2025c; Global Policy Watch, 2025). Storage therefore counts only as an add-on to new generation and only if the auctioneer chooses this criterion. New or updated electric vehicle subsidy schemes must also favour vehicles with components from diversified sources of supply, through reducing dependence on a single dominant supplier country. Cobalt, lithium and nickel come from highly concentrated supply chains, so sodium-ion batteries, for example, have the chance to score better by default. The rule sets no target, however and Member States decide its weight. The third instrument is the 'Made in the EU' pillar of the Battery Booster Strategy, targeting EU origin content. However, it is not binding and would need the Industrial Accelerator Act to become so (see Section 5.1). Low-CRM batteries therefore only benefit from these instruments if they are cost-competitive.

Two binding rules give low-CRM batteries an incidental advantage. The Battery Regulation sets recycled-content quotas for cobalt, lithium and nickel. It also requires due diligence, meaning supply-chain mapping and third-party audits, for cobalt, lithium, nickel and natural graphite. Batteries that contain none of these materials, such as nickel-free sodium-ion or vanadium flow batteries, are exempt from both duties. The advantage is weak. The quotas are modest and only start in 2031. By then, new batteries must contain at least 16 percent recycled cobalt, 6 percent lithium and 6 percent nickel. By 2036, the minimum rises to 26, 12 and

15 percent (BEPA, 2023; IEA, 2023). The exemption only spares low-CRM producers a compliance burden. It creates no demand and provides no funding. The CRMA adds little. Its substitution category has no quantified benchmark and has hardly been used (see Section 5.2 A).

Two gaps remain. The existing rules show that conditions can be attached to demand, but none of them rewards low CRM content. No instrument covers the higher cost of low-CRM batteries either. A lead-market instrument for low-CRM batteries therefore has to do both: create demand and close the cost gap. These are the starting points for the proposal in Section C.

B) Best Practices

Two examples from outside the battery sector show how price certainty and public demand can be created within EU law.

Germany's Klimaschutzverträge show that CfDs can work at scale under EU state aid rules. The Commission approved the scheme in early 2024 as the first of its kind. Its first round used a €4 billion budget for 15-year contracts with decarbonisation projects in steel, cement, chemicals and glass (BMWK, 2024a). Projects are selected by competitive auction, based on the cost per tonne of CO_2 avoided. The contracts cover only the additional cost of a climate-friendly plant compared to a conventional one. A dynamic price adjustment protects against changes in input costs such as hydrogen and electricity. This structure could be transferred to a CfD for low-CRM batteries. The first round also shows a limit. It attracted only 17 bids and about €1.2 billion of the budget remained unallocated (BMWK, 2024). Even a broad scheme can struggle to create real competition.

Sweden's Trafikverket shows how public procurement can reward lower emissions in construction projects. Since 2015, the transport infrastructure authority has required a life-cycle emissions calculation, using its own tool, for construction projects worth €5 million or more. For smaller projects, it requires product-level Environmental Product Declarations for the construction materials (Stockholm Environment Institute et al., 2023). On top of the climate requirements, contractors can earn a bonus when they beat them, for example for low-emission concrete or renewable fuels. The bonus is paid after the work is completed and the result is verified (Blomqvist et al., 2023).

The OECD names four conditions for green public procurement to work at scale. These are a common measurement standard, legal room for non-price criteria, a way to offset the higher cost and enough administrative capacity (OECD, 2024). For batteries, the first two already exist. The Battery Regulation introduces a carbon footprint declaration that public buyers can compare, much like Trafikverket's tool (European Commission, 2023a). The EU Public Procurement Directive (2014/24/EU) already allows non-price award criteria. The third condition is still missing, a mechanism that offsets the higher price of a cleaner bid.

C) Policy Proposal 2: How to Enable Lead Markets for Next-Generation Batteries

Next-generation batteries produced in the EU are still more expensive than conventional ones and producers lack secure buyers. Two instruments address this from both sides. Contracts for Difference remove price risk, because they give producers a stable price per unit. Public procurement removes volume risk, because a binding purchase commitment gives producers a confirmed buyer. This section sets out what each instrument should contain and which design choices remain open.

Both use the same eligibility criteria as Proposal 1, the CRM vulnerability score and production in Europe (see Section 5.2 C).

How to Enable Lead Markets for Next-Generation Batteries

01 Setting the eligibility criteria

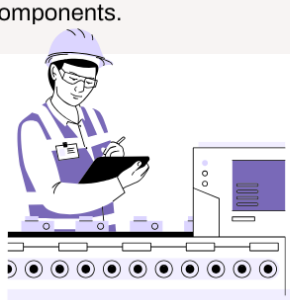
Critical raw material (CRM) vulnerability

Score 3 (high) to 1 (low), based on which CRMs a chemistry uses and how exposed their supply chains are. The rating method is transparent and reviewed regularly. Applicants document their chemistry with battery passport data. In the long term, a maximum score of 2 applies.

Priority for 'Made in the EU' production

WTO-compliant, so non-EU suppliers cannot be fully excluded. Dependence on any single non-EU country could be capped, as in the Net-Zero Industry Act (NZIA). 'Made in the EU' should be defined uniformly, for example by value added or share of components.

02 Designing the instrument



Contracts for Difference (CfDs)

A strike price for the production of next-generation batteries is set in advance. As long as the reference price is lower, the state subsidises the difference. If it is higher, the producer pays the surplus back.

- **Reference price:** Based on a conventional benchmark battery.
- **Strike price:** Based on the production costs of low-CRM batteries.
- **Price unit:** A comparable unit, such as kWh of storage capacity produced or kWh over the battery's lifetime.
- **Price path:** The strike price declines along a path set in advance, based on industry-wide cost trends.
- **Selection:** Auctions with weighted scoring of price and non-price criteria.
- **Volume and budget cap:** Fixed kWh per contract and fixed budget per multi-year round.
- **Delivery obligations:** Milestones and penalties if producers fail to deliver.
- **Time frame:** A fixed duration of several years.

Public procurement

Public authorities and utilities buy goods through competitive tenders. A low-CRM battery producer that wins a tender secures a binding purchase commitment for a fixed volume.

- **Scope:** Defines which public authorities and utilities must apply the rules.
- **Selection:** Bids are scored on price and on non-price criteria, such as CRM vulnerability.
- **Origin:** The cap on dependence on a single non-EU country already applies to industrial batteries in procurement (NZIA).
- **Further criteria:** For example, price over the full life cycle or per kWh of capacity (quality criterion).
- **Form:** Individual storage projects or multi-year framework agreements.

03 Implementing the instrument

- **EU framework:** Criteria & rating for the vulnerability score and 'Made in the EU', State aid approval of the CfD, common rules for procurement criteria, monitoring.
- **National implementation:** CfD with a budget cap and an auction body, low-CRM criteria in public procurement, joint procurement and framework agreements, market surveillance and monitoring.

Note: Step 2 sets out the design choices that have to be defined for the instrument to work, grouped by category.
Source: KONTEXT Institute (2026): Beyond Critical Raw Materials: Scaling Next-Generation Batteries in Europe.

The proposed policy creates a lead market for next-generation batteries. It combines two instruments that act on different sides of the market. Contracts for Difference remove price risk, because they give producers a stable price per unit. Public procurement removes volume risk, because a binding purchase commitment gives producers a confirmed buyer. Both of them give producers a secure market. The lead-market instruments use the same two eligibility criteria as Proposal 1.

The CfD closes the cost gap by securing a stable price. The reference price follows the cost of a conventional benchmark battery. The strike price follows the production costs of low-CRM batteries and lies above the reference price. Both are set per comparable unit, so different technologies are measured the same way. This can be kWh of storage capacity produced or, to reflect durability, the total kWh a battery can store over its rated cycle life. If the reference price is below the strike price, the state pays the difference. If it rises above, for example after a lithium price shock, the producer pays the surplus back. The strike price follows a declining path that is fixed in advance and based on industry-wide cost trends. Producers therefore have an incentive to become more efficient and to build a business model that works after the CfD ends, while the price they receive stays stable until then. Contracts are awarded in auctions that score price and non-price criteria. Each round has a fixed volume in kWh of battery capacity and a fixed budget, so public spending stays predictable. Producers commit to milestones for delivery and for approaching the cost of conventional batteries, with penalties if they miss them. Contracts run long enough for producers to stabilise their costs and establish themselves in the market. Germany's Klimaschutzverträge, for example, run for 15 years (BMWK, 2024b).

Public procurement secures demand. A producer that wins a tender gets a guaranteed buyer for a fixed volume. The scope defines which public authorities and utilities must apply the rules and therefore how large the demand is. As in the CfD, bids are scored on price and on non-price criteria such as CRM vulnerability, so a low-CRM battery can win even if its production costs are higher. Combined, the two instruments provide the cost offset the OECD calls for. Where a CfD already covers the price premium, the producer can bid at the conventional price and its lower CRM vulnerability decides the tender. Public buyers then pay the conventional price, so the premium is not paid twice. For battery and energy storage technologies, the NZIA already requires public buyers to limit dependence on a single dominant non-EU supplier (European Commission, 2024a). Buyers can add further criteria. Life-cycle costing, which the Public Procurement Directive explicitly allows, compares bids on their real cost over the battery's lifetime rather than on purchase price alone. Prices per kWh of capacity make different technologies comparable. Multi-year framework agreements give producers planned demand over several years, while single projects cover one-off needs.

The EU sets the standards and Member States fund and run the instruments. The Commission defines the CRM vulnerability rating and the 'Made in the EU' measure. It approves national CfD schemes under state aid rules, gives common guidance on procurement criteria and monitors how the instruments are used. Member States set up the CfD with a budget cap and an auction body. They also define contract details such as duration, strike price and reference price. They apply the criteria in public tenders, including those of regional and local buyers and can bundle demand through framework agreements and joint procurement. Market surveillance checks that battery passport data and low-CRM claims are correct. Together, the two instruments meet all four criteria.

5.4. Enabler 3: Setting Clear Rules

What is a regulatory framework?

A regulatory framework is the set of goals, rules and responsibilities that gives policy its direction. It defines where an industry should go and who is responsible for getting there. For next-generation batteries in the EU, it is a largely invisible foundation. It neither pays for factories nor creates demand. New technologies, however, often face regulatory gaps, unclear rules, or rules designed around established technologies. Early technologies build up advantages through scale, learning and infrastructure, even where better alternatives may exist (Arthur, 1989). Over time, technologies, institutions and habits reinforce each other (Seto et al., 2016). A regulatory framework can correct this in two ways. It can build rules that do not yet exist, such as targets, standards and data requirements. It can also remove biases from rules written with only the established technology in mind. The framework also includes its governance: who decides, how progress is tracked and how the rules are adapted over time. Capital (Enabler 1) and demand (Enabler 2) act on cost and risk. This enabler sets the direction they follow. It therefore does not describe a single policy. It lists the components that a framework and its governance should cover.

A) What Exists in the EU

Most existing rules were set for energy storage in general, not for a particular chemistry or for reducing CRM dependency. This section looks at four areas: storage targets, estimates of storage needs, harmonised rules and transparency.

The EU has no binding target for energy storage. Renewable energy has a binding EU target under the Renewable Energy Directive (RED III). For Storage, the Commission's AccelerateEU Communication only sets a non-binding benchmark of 200 GW by 2030. The Storage Tripartite Agreement adds national pledges. It brings together governments, promotional banks, developers and energy-intensive industries. In 2026, 22 Member States signed it, with pledges for 2026 to 2028 measured against the 200 GW benchmark. These pledges create no legal obligation (European Commission, 2026b). The National Energy and Climate Plans (NECPs) could anchor such targets, but storage is not one of their mandatory dimensions. In the draft plans, only eleven Member States quantified storage for 2030. Only Spain set a technology-neutral storage target backed by a dedicated strategy (Ember, 2024).

Estimates of storage needs are only now emerging and none links them to EU production. Under the Flexibility Needs Assessment (FNA), each Member State had to assess by July 2026 how much flexibility its power system needs to balance supply and demand. By January 2027, Member States must use the result to set an indicative national target for non-fossil flexibility (ACER, 2026). This target must specify a separate contribution from energy storage (European Commission, 2019). There is, however, no battery-specific target for EU production. The NZIA only sets a general benchmark: 40 percent of the EU's annual deployment needs for all net-zero technologies should be manufactured in the EU (European Commission, 2024b). No goal links storage demand to EU battery production.

Harmonised rules exist in law but are applied unevenly. EU-wide technical rules govern how storage connects to the grid, from both the generation and the demand side (European Commission, 2016). The Electricity Market Regulation requires non-discriminatory market access for storage. Safety standards for stationary battery storage are being developed under a CEN-CENELEC standardisation request (ECOS, 2022). Once a product meets harmonised safety standards, it can in principle be sold anywhere in the EU. In practice, Member States apply these rules differently. Some treat storage as generation, others as load. In some, operators pay grid fees twice, once when charging and once when discharging. Licensing procedures also differ. This fragmentation complicates cross-border deployment (Sánchez-Sánchez et al., 2026). Standards for new chemistries are only starting to

emerge. A first harmonised standard for electric vehicle battery modules now includes sodium-ion (European Commission, 2026a).

The battery passport will collect CRM data, but its value depends on implementation. From February 2027, electric vehicle, light-means-of-transport and industrial batteries above 2 kWh must carry a passport that publicly lists their chemistry and the critical raw materials they contain ((European Commission, 2023b)). How useful it is depends on how the data are collected and who can access them. Industry has called key terms such as "detailed composition" too vague (Eurobat, 2024).

Four gaps remain. The EU lacks storage targets that give the market a direction and no target links storage demand to EU battery production. Rules are not applied in the same way across Member States. CRM data will exist but are not yet used to steer policy. And no clear governance structure brings these parts together. The proposal in Section C is built around these four gaps.

B) Best Practices

The following examples show how goals, harmonised rules and transparency can work in practice.

Spain shows how a national plan can carry a concrete storage target. Its Energy Storage Strategy of 2021 foresaw 20 GW of storage by 2030. The updated National Energy and Climate Plan (PNIEC), adopted in September 2024, raises this to 22.5 GW. It foresees an indicative split of 12.5 GW of daily and weekly storage and 10 GW of seasonal storage (BOE, 2024; MITECO, 2024). The plan also names the means to get there: new pumped-hydro storage, capacity markets and a reform of the electricity market. Spain has since established a capacity market by ministerial order, in which storage can take part. The plan sets a number and an instrument, but it does not address where the batteries are to be made.

EU vehicle type-approval shows how harmonised rules can be applied the same way everywhere. Under Regulation (EU) 2018/858, a manufacturer applies once, to one national authority and the approval is recognised in all Member States (European Commission, 2018). The Regulation does not leave consistent application to chance. The Commission audits and oversees the national approval authorities, a Commission-run forum lets Member States exchange enforcement practice. Regular audits of manufacturers' production are mandatory. A product that meets the rules can therefore be sold everywhere and the authorities that decide this are held to a common standard. For batteries, the Battery Regulation already contains tools of the same kind. It sets common safety requirements for stationary battery storage systems and a single EU methodology for the carbon footprint, to be fixed in a delegated act (European Commission, 2023a).

The ENTSO-E Transparency Platform shows how equal access to data levels the playing field. Commission Regulation (EU) No 543/2013 requires a common minimum set of electricity market data to be made available to all market participants free of charge (European Commission, 2013). The data are published on the ENTSO-E Transparency Platform, which has been in running since 2015 (ENTSO-E, 2026). Its aim is to give new and established participants equal access to timely information (Andersen & Anandha, 2025). Access to data therefore does not depend on market position. The battery passport can play a similar role for product data. From 18 February 2027, industrial batteries above 2 kWh, electric vehicle batteries and batteries for light means of transport must carry one (Art. 77). Its public part covers, among other items, chemistry, rated capacity, carbon footprint and critical raw material content, in the same fields for every chemistry (European Commission, 2023b). A producer of a new, low-CRM chemistry can then be compared directly with established lithium-ion suppliers. The passport only applies from February 2027 and the implementing act on access rights has been delayed (EU Digital Product Passport Foundation, 2026).

C) Policy Proposal 3: How to Set a Regulatory Framework for Next-Generation Batteries

This proposal addresses these four gaps in three building blocks: storage targets with a clear path, harmonised standards and monitoring, transparency and governance. Together, they give producers, investors and grid operators a reliable basis for planning. This section sets out what each building block should contain and which design choices remain to be made.

Storage targets with a clear path give the market a direction. The deployment target should be derived from a meta-analysis of storage needs up to 2040. A matching EU production target for battery capacity links this demand to European manufacturing. Both targets are broken down into annual steps, so progress becomes measurable every year. Making them legally binding gives investors and the whole industry a credible signal. All Member States should calculate their storage needs with the same transparent method and shared data, for example through the Flexibility Needs Assessment from 2027. The figures are then traceable and comparable between countries.

How to Set a Regulatory Framework for Next-Generation Batteries

Storage targets with a clear path	■ **Binding targets and paths:** Deployment and production targets up to 2040, in annual steps. ■ **Common method:** The same transparent calculation of storage needs in all Member States. ■ **National anchoring:** Storage becomes a mandatory part of the National Energy and Climate Plans (NECPs). ■ **Differentiation:** Sub-targets per battery type or industry.
Harmonised standards	■ **Common requirements:** One EU set of rules for safety, performance, durability and grid connection, valid in every Member State.
Monitoring, transparency and governance	■ **Deployment and production data:** Yearly tracking per technology. ■ **Critical raw material data:** Battery passport, carbon footprint method and CRMA* and supply chain monitoring ■ **Transparency:** Public data and a yearly report comparing Member States. ■ **Governance:** National storage and battery strategy with an action plan and clear responsibilities.
Implementing the framework	■ **EU framework:** Binding targets and common method, harmonised standards, battery passport and monitoring, yearly report. ■ **National implementation:** NECPs with storage section, national storage and battery strategy with an action plan, market surveillance, national data reporting.

Note: *CRMA = Critical Raw Materials Act
Source: KONTEXT Institute (2026): Beyond Critical Raw Materials: Scaling Next-Generation Batteries in Europe.

Storage also becomes a mandatory part of the NECPs, building on the figures Member States already have to set. Sub-targets per application or industry, such as short- and long-duration storage, make clear which technology serves which purpose best. This gives industry clarity and gives long-duration technologies such as flow batteries a visible share of demand.

Harmonised standards allow a battery approved in one Member State to be used in all of them. The EU should set one common set of requirements for safety, performance, durability and grid connection. A battery that meets them in one Member State then meets them in all others. With common grid connection rules, a Spanish manufacturer could supply Austrian grids, technically as well as legally. For new chemistries such as sodium-ion and different flow batteries, standardisation requests should close the remaining gaps quickly, so these technologies get a clear and fast certification route.

Monitoring, transparency and governance show whether the framework works. Deployment and EU production should be tracked every year per technology. This shows whether the targets are met. CRM data from the battery passport, the carbon footprint method and CRMA monitoring show how CRM use in batteries develops. The same data serves as proof of eligibility for Proposals 1 and 2 and as input for the regular review of the CRM vulnerability rating. The data are published together with a yearly report that compares progress across Member States, so results are visible to investors, producers and the public. Each Member State also sets up a storage and battery strategy with an action plan for reaching its deployment and production targets. The strategy names the responsible authorities and their tasks.

The EU sets targets, method and standards and Member States turn them into national strategies. The Commission proposes the binding targets, defines the common method for calculating storage needs, issues standardisation requests for new chemistries and publishes the yearly report. Member States include storage in their NECPs, adopt national strategies with action plans and apply the common standards. Much of this builds on existing processes, such as the Flexibility Needs Assessment, the NECPs, the CEN-CENELEC standardisation request and the battery passport. Binding targets and a mandatory storage section in the NECPs, however, require new legislation.

How the Proposals Meet the Criteria

Taken together, the three proposals meet the four criteria set out in the methodology: higher production, closing the cost gap, a focus on low-CRM products and legal feasibility. No single proposal satisfies all four on its own; each covers a different core. Risk capital for production and scaling raises output by financing pilot lines, capacity and ramp-up. It is legally feasible because the CISAF state aid framework already provides for such instruments. It lowers the cost of capital but does not close the cost gap directly. Lead markets address this gap. Contracts for Difference (CfD) compensate the price difference to conventional batteries and secure a stable price, while public procurement creates demand. Both use the eligibility criteria to target low-CRM chemistries. Procurement fits within existing procurement law, whereas a CfD still requires state aid approval. The regulatory framework neither raises production nor closes the cost gap directly. It provides the basis for the other two proposals: binding targets and common standards give planning certainty, and monitoring shows whether low-CRM batteries gain ground, so that the instruments can be targeted and evaluated. Binding targets would require new EU legislation, which makes this proposal the weakest on legal feasibility. The proposals therefore complement each other and, in combination, cover all four criteria.

6. Case Study: National Implementation in Austria

Whether EU policies take effect in practice depends on how Member States implement them. Regulations apply directly in all Member States, while directives must first be transposed into national law. For directives, delays depend on domestic factors. These include the number of national measures needed, whether an act of parliament or a ministerial decree is required and federal political structures (König & Luetgert, 2009). Regulations can also be demanding to implement. For the battery passport, industry reports incomplete guidance, standards still under development and strain on smaller companies' digital capacity and on auditors (Global Battery Alliance, 2026).

Several of the EU policies discussed above already reach Austria. The Battery Regulation and the Net-Zero Industry Act are regulations and apply directly. The Clean Industrial State Aid Framework (CISAF) is optional and Austria already uses parts of it for cleantech manufacturing (European Commission, 2025e). In the electricity sector, Austria transposed the EU electricity market directives with the Electricity Act (ElWG) of December 2025, which includes a dedicated section on energy storage (Austrian Parliament, 2025). The Industrial Accelerator Act, by contrast, is still a Commission proposal.

Austria's need for battery storage will grow strongly. According to a 2025 study by Austrian Power Grid, PV Austria, TU Graz and d-fine, Austria will need about 8.7 GW of battery storage by 2040, up from just over 1 GW today (Wiedner et al., 2025). Of this, 2.7 GW would be large-scale storage and 6 GW decentralised small-scale storage. Pumped hydro storage remains essential alongside batteries. Meeting this demand with low-CRM batteries requires all three enablers, from supporting local producers to deploying their products where they fit best.

This chapter applies the three enablers to Austria. For each enabler, it shows which tasks lie with Austria and which with the EU, and where Austria has opportunities and faces challenges. The findings are based mainly on the third expert workshop in Vienna, complemented by own research.

Enabler 1: De-Risking Capital Investments

Austria is responsible for setting up the funds and guarantees and for deciding their size and terms. Proposal 1 helps start-ups and scale-ups raise capital for production and scale-up through co-investment or portfolio loan guarantees (see Section 5.2). The EU sets the common eligibility criteria for CRM vulnerability and 'Made in the EU' production, the state aid and financial rules under CISAF and minimum design standards. Austria sets up the funds and guarantees through national promotional institutions such as aws *(Austria Wirtschaftsservice GmbH).* Within CISAF, it also sets budget caps and concrete terms, such as the number of guarantees, the payout budget per portfolio, time frames and fees.

Instrument	National opportunities: What exists and works?	National challenges: What is missing or hinders implementation?
Co-investment and portfolio loan guarantees	■ **Experience with funds and guarantees:** The *'aws'* has the instruments, the experience and a state-private start-up fund. It already offers guarantees of up to 80 percent of a loan (WKO, 2026a). ■ **Experience with CISAF:** The aws programme TWIN Transition is based on CISAF and covers battery and energy storage technologies (BMWET, 2025). ■ **A clear gap to close:** Early-stage funding is well developed in Austria, but scale-ups find little capital (BMWET, 2025). ■ Available private capital: About 35 percent of Austrian household financial assets are held in deposits (OeNB, 2025) and much of it does not reach young companies. ■ **Flexible terms:** Caps, time frames and fees can be set in national funding guidelines, as in the aws guarantee guideline.	■ **Limited budget:** Austrian state aid budgets are small. The instruments need a clear financial framework with ceilings and should mainly mobilise private capital. ■ **Approvals and timing:** New funding guidelines must be agreed with the Ministry of Finance. Also funding approvals for companies can take months. Both could delay the start.

Table 4: National implementation of co-investment and portfolio loan guarantees

Enabler 2: Building Lead Markets

Austria is responsible for running the CfD and for applying eligibility criteria in public procurement. Proposal 2 creates demand for low-CRM batteries through Contracts for Difference and public procurement (see Section 5.3). The EU sets the eligibility criteria, approves the CfD under state aid rules, sets common rules for procurement criteria and monitors the instruments. Austria sets up the CfD with a budget cap and an auction body. It applies low-CRM and Priority of 'Made in the EU' criteria in public procurement, organises joint procurement and framework agreements and carries out market surveillance and monitoring.

Instrument	National opportunities: What exists and works?	National challenges: What is missing or hinders implementation?
Contracts for Difference	■ **An existing auction body:** The *'EAG-Abwicklungsstelle'* runs the auctions under the Renewable Energy Expansion Act (EAG). Renewable producers bid for a market premium, and the lowest bids win until the volume is used up (Rajal & Schneider, 2021). A CfD for next-generation battery producers could reuse this process. ■ **A proven instrument:** CfDs are already used in Europe. Germany's Klimaschutzverträge run for 15 years on the basis of a funding guideline, without a separate law, and were approved by the European Commission (Deutscher Bundestag, 2023).	■ **No programme or design yet:** A CfD for next-generation batteries would need its own funding programme, a budget, possibly a new law and Commission approval. The product, the price unit and the reference price still need to be defined.
Public Procurement	■ **A green procurement framework exists:** Federal bodies generally apply the 'naBe' criteria, to which EU-wide award criteria could be added (European Commission, 2014; WKO, 2026b). ■ **A central purchasing body:** Federal bodies generally must buy certain goods through the 'Bundesbeschaffung GmbH (BBG)'. A framework agreement for low-CRM storage could pool demand (Rechnungshof Österreich, 2023).	■ **Extension of naBe needed:** Storage is not yet a naBe product group. The 2025 evaluation advises against adding product groups before monitoring is automated (Hofbauer et al., 2025). ■ **Binding only at federal level:** Austrian federal states (*'Länder'*) and municipalities, the main buyers, only have a voluntary commitment and little willingness to pay more.

Table 5: National implementation of Contracts for Difference and public procurement

Enabler 3: Setting Clear Rules

Austria can set its own storage targets and strategy, while standards are set at EU level. Proposal 3 sets storage targets, harmonised standards and rules for monitoring (see Section 5.4). The EU proposes the binding targets and the common method, issues standardisation requests, sets the rules for the battery passport and publishes the yearly report. Austria anchors storage in its NECP, adopts a national storage and battery strategy with an action plan, carries out market surveillance and reports national data. Harmonised standards are not covered here, since they are an EU responsibility.

Instrument	National opportunities: What exists and works?	National challenges: What is missing or hinders implementation?
Storage targets	■ **National competence:** Austria can set its own storage strategy with goals and monitoring, ideally per sector or technology. ■ **An expert basis:** First national estimates exist, such as the 8.7 GW of battery storage needed by 2040 (Wiedner et al., 2025).	■ **Unclear focus:** It is open how battery-specific policy relates to general industrial policy and whether the industry should serve the home market or the world market.
Monitoring, transparency, governance	■ **The battery passport applies directly:** As an EU regulation, it applies from February 2027. Austria's task is enforcement, and the draft law names the climate ministry as market surveillance authority (Parlament Österreich, 2026).	■ **Unclear responsibility:** Workshop participants noted that responsibilities for governance processes are still unclear, in general and for storage in particular.

Table 6: National implementation of storage targets and monitoring

Austria can start implementing all three enablers under existing rules, but the common basis must come from the EU. Austria can build on its aws instruments and its experience with CISAF for co-investment and guarantees. It can prepare low-CRM criteria for its procurement framework, use its auction experience for a CfD and set national storage targets and monitoring based on existing expertise. Without common EU criteria, however, national definitions would differ between Member States and fragment demand. The EU therefore needs to provide the eligibility criteria and their calculation method, state aid approval, a harmonised method for assessing storage needs, data transparency and harmonised standards. National action and EU rules complement each other.

7. Conclusion

Batteries are key to making renewable energy available when it is needed, but today they put Europe in a double dependency. Renewable energy can free Europe from its dependence on oil and gas, but only if its power is available when it is needed. Storage closes this gap, and batteries are its fastest-growing part. Most of them, however, are lithium-ion batteries produced outside Europe, mostly in China. They also rely on critical raw materials (CRMs) with vulnerable supply chains.

Next-generation batteries can turn this dependency into an industrial opportunity. They use as few CRMs as possible, and their market is not yet dominated by any single country or company. The window to build a European industry is therefore open now. Existing EU policy, however, does not yet target these batteries.

This report examined how the EU can scale up low-CRM batteries. It addressed three questions: which low-CRM battery technologies already exist, which barriers keep them from scaling up in the EU, and which policies can remove the most pressing barriers. To answer them, it combined a literature review, interviews with eight battery producers from five EU countries and three expert workshops in Brussels and Vienna.

Low-CRM alternatives already exist, and several are ready to scale. Metal-ion, metal-sulfur, metal-air and redox-flow batteries each reduce or replace CRMs in a different way. Sodium-ion batteries are Europe's clearest near-term opportunity. They are mature, have a low CRM vulnerability and suit electric mobility and short-duration storage. Vanadium flow batteries are commercially mature and suit long-duration stationary storage, despite a moderate CRM vulnerability. Iron-based, zinc-bromine and organic flow batteries avoid CRMs altogether and can follow as they mature. No single technology fits every use case. Europe therefore needs a portfolio of technologies, each used where it fits best.

The main barriers lie on the way from prototype to market. The report identifies seven barriers: gaps between research and industry, missing early-stage capital, uncertain demand, shortage of skilled workers, underdeveloped supply chains, slow substitution of critical raw materials and missing and unclear rules. Three of them are most pressing: capital, demand and rules. Producers need risk capital to cross the 'valley of death' between prototype and industrial production. They need secure demand for products that are still more expensive than lithium-ion batteries. And they need clear rules that set a direction for the whole industry. Europe's solar industry shows how quickly an industrial lead can be lost when such support is missing or ends too early.

Existing EU instruments do not close these gaps. They are chemistry-neutral and mostly reward where a battery is made, while hardly considering what it is made of. Their 'Made in the EU' rules are not yet binding, and funding mainly reaches large projects rather than the young companies that develop most low-CRM technologies.

The report therefore proposes three policies that share the same eligibility criteria. Support only goes to producers with a low CRM vulnerability score and production in Europe, with a cap on dependence on any single non-EU country.

- **De-risking capital investments:** Direct co-investment and portfolio loan guarantees share the risk of building pilot lines and production capacity. Public money only flows alongside private capital, which provides at least half of the funding.
- **Creating lead markets:** Contracts for Difference give producers a stable price per unit. Public procurement gives them a confirmed buyer.
- **Clear rules:** Binding deployment and production targets, a common method for calculating storage needs, harmonised standards, yearly monitoring and national storage strategies give the industry a direction.

Together, the proposals cover the path from pilot line to market. Access to private and publicly guaranteed risk capital helps producers build their first production capacity. Lead markets make sure they can sell what they produce. Clear rules give investors and producers a reliable direction. The CRM vulnerability score ensures that support goes to batteries that actually reduce Europe's dependence on CRMs. Much can start now, because the proposals build on existing instruments: the Clean Industrial State Aid Framework (CISAF) for State aid; the Public Procurement Directive and the Net-Zero Industry Act (NZIA) for non-price criteria; and the battery passport for CRM data. Some elements need further EU decisions. The Contracts for Difference (CfD) need state aid approval, binding storage targets need new legislation, and CISAF has to be extended beyond 2030.

Austria shows that Member States should not wait to prepare implementation at national level. It will need about 8.7 GW of battery storage by 2040, up from just over 1 GW today. It can already offer co-investment and guarantees under CISAF. Once harmonized and defined at EU-level, it can add eligibility criteria to its green procurement framework. It could use its auction body under the Renewable Energy Expansion Act (EAG) for the development of a CfD for next-generation battery producers and adopt a national storage strategy. EU action remains necessary for origin rules, State aid approval, comparable calculation methods, data and standards. National and EU action therefore complement each other.

Europe still has the chance to build a battery industry of its own. Low-CRM batteries can make renewable power available when it is needed, reduce Europe's dependence on critical raw materials and create industrial value at home. To use this chance, the EU and its Member States need to act while the market is still open.

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