Consideration for European Battery SRIA 2025

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EXECUTIVE SUMMARY

Battery technology is key to the green energy transition as it can enable both our transport and stationary storage sectors ensuring low emission transport and affordable energy for Europe. The Battery technology sector is growing significantly in Europe and much of this is due to our ability to adapt and innovate. Research and Innovation is at the heart of the success of the battery industry globally. Of course, as with any new industry development, the battery industry will experience some failures along the road to success way, however these failures do not define us as an industry or as a research community. We at Batteries Europe ETIP have been first hand witnesses to the resilience of the many experts working in the sector.

While this final document for this mandate of the Batteries Europe ETIP does not constitute a Strategic Research and Innovation Agenda (SRIA) as initially envisioned, it offers substantial insights into the policy and status of the battery sector, contributing significantly to the development of SRIA 2025, which will be completed by BEPA (Battery European Partnership Association). The 2025 Roadmap of Batteries Europe ETIP also provides crucial technical input for the SRIA of 2025.

Following an overview of Batteries Europe ETIP's achievements in Chapter 1, this document delves into the policies in Chapter 2 and battery regulations in Chapter 3, that significantly impact the battery sector in Europe. We examine the ongoing and anticipated changes in policy and legislative additions to the regulation, which are poised to influence the sector profoundly.

Chapter 4 addresses the SET Plan and the robust connections Batteries Europe ETIP has cultivated across the NRCG (National and Regional Coordination Group) with a focus on batteries. The development of the battery industry in Europe and abroad, particularly in cell manufacturing, is evolving rapidly, as discussed in Chapter 5. However, it is noteworthy that no homegrown European battery gigafactory has yet successfully completed the production ramp-up. This chapter provides a brief assessment of the current situation.

Education and skills development remain critical challenges for the European battery value chain. Chapter 6 suggests methodologies to address these issues effectively. Looking ahead, Social Science and Humanities (SSH) issues will gain increasing importance. Chapter 7 highlights examples of where SSH can contribute meaningfully.

Finally, Chapter 8 consists of an acknowledgements section, where we recognise the initiative of the European Commission, the JRC and the contributions of over 800 stakeholders in Batteries Europe.

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1 Overview of Batteries Europe

In 2019, Batteries Europe ETIP was established to fulfil a pivotal task of the European Battery Alliance (EBA): uniting a community to develop Technology Roadmaps, Key Performance Indicators (KPIs), and a Strategic Research and Innovation Agenda (SRIA) for European battery stakeholders. The ETIP has been structured into six Working Groups of experts, encompassing the entire battery value chain, alongside six Task Forces addressing transversal topics to foster cross-collaboration among the working groups, as listed in Figure 1.

Figure 1. Six Working Groups (Left) and Six Task Forces (Right) of Batteries Europe ETIP

The establishment of the first Batteries Europe ETIP Secretariat was supported by a European Commission tender, running from Spring 2019 to Spring 2021. By 2021, Batteries Europe ETIP was firmly established, and the European Commission agreed to support the platform by providing resources for a Secretariat, which competed for the Horizon Europe CSA project. This project has spanned from May 2022 to April 2025, finalising with this last report.

While this final deliverable for this mandate of the Batteries Europe ETIP does not constitute a Strategic Research and Innovation Agenda (SRIA) as initially envisioned, it offers substantial insights into the policy and status of the battery sector, contributing significantly to the development of the SRIA 2025, which will be completed by BEPA. The 2025 Roadmap of Batteries Europe ETIP provides crucial technical input for the SRIA. Given the rapid advancements in battery technology and the sector's growing importance, the European battery community has also evolved. We have swiftly adapted our work streams to collaborate efficiently, with each member assuming distinct and vital roles. In the foreseeable future the role of organising the Work Groups and Task Forces will become a role which BEPA will fulfill.

Batteries Europe ETIP has played a crucial role in coordinating with member state representatives in the National and Regional Coordination Group (NRCG), facilitating the exchange of information through face-to-face meetings, webinars, and contributions to the SET Plan reporting. The NRCG serves as a vital instrument for ensuring effective communication between national and European levels.

In addition to cultivating a comprehensive understanding of the battery research landscape within Europe, the Batteries Europe ETIP has also focused on examining advancements in battery technology beyond European borders. A member of the Batteries Europe secretariat, accompanied by representatives from the EBA (European Battery Alliance), BEPA (Battery European Partnership Association), and the IPCEIs (Important Projects of Common European Interest) on Batteries, embarked on missions to Asia and North America. These endeavors facilitated the establishment of

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valuable contacts and subsequently bolstered several countries' participation in the Horizon Europe research program. The principal findings were disseminated at our events, and through a series of fact sheets available on our website.

Over the past six years, the Batteries Europe website[1] has flourished, becoming an excellent source of information for those interested in battery research across the value chain. In addition, to providing access to our Technology Roadmaps, Task Force position papers, KPI benchmarking, the Strategic Research and Innovation agenda (SRIA), and international fact sheets, we have introduced a section dedicated to Battery Network Resources. This section offers a comprehensive list and details of all currently running EU-funded projects on batteries, an overview of 13 national battery research programs, and the names of numerous national battery networks and associations across various European countries. While this list is not yet exhaustive, it represents a significant step towards presenting a holistic view of the battery industry and research landscape in Europe.

Figure 2 Logo and advertisement of Battery Innovation Days 2024

In collaboration with prominent European battery initiatives such as BEPA, Battery 2030+, and the two IPCEIs on batteries, an annual two-day event known as the Battery Innovation Days has been established since 2022 See figure 2. This yearly event facilitates dialogue among the research community, policymakers, industry players and end-users to boost battery research and innovation in Europe. The meeting hosts panel debates concerning all aspects of innovation along the battery value chain. It also has a poster session, a young battery scientist awards ceremony and highlights the findings of the European battery projects. The aim of the Battery Innovation days is to increase knowledge and encourage exchange around the deployment of cutting-edge technologies in battery materials, cell design, manufacturing and recycling.

Batteries Europe ETIP has provided a platform for network building, strengthening the European battery industry, sharing technical knowledge and ideas, and contribution to the European Battery R&I strategy which has been open to all to join. It has also contributed to support job creation and allowed stakeholders to play a significant role in the green energy transition. One side effect of this collaboration are the many friendships between people with diverse backgrounds which are developed over the years.

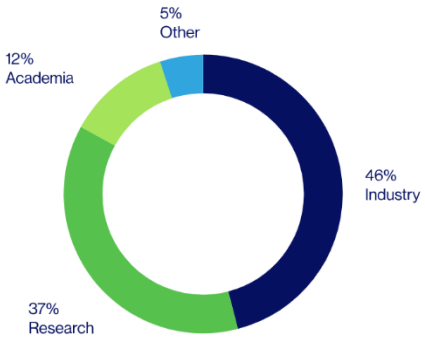

Figure 3. Stakeholders background involved in Batteries Europe ETIP

The success of Batteries Europe ETIP is reflected in the dedication of 800 active stakeholders, from over 300 organisations to the activities of the network. Figure 3 shows the composition of the varying backgrounds of stakeholders. Our hope is that these stakeholders will continue to contribute via BEPA engagement in the coming years. The platform's documents, including Roadmaps, SRIAs, Position Papers, Technical KPIs, and Reporting Methodologies, remain accessible on the Batteries Europe website[1]

[1] Batteries Europe – www. batterieseurope.eu

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2 Policy Agenda and its Impact on the European Battery Industry

After the renewal of the EU political leadership in 2024, Ursula von der Leyen kicked off her new mandate at the head of the European Commission and, within the first 100 days, clearly set out her political priorities for the next five years. While industrial competitiveness and decarbonisation are placed at the top of the agenda, starting with the publication of the Clean Industrial Deal, the Commission remains committed to the Green Deal ambition and policies. The work on the next Multiannual Financial Framework (2027-2034) including the Framework Programme for Research and Innovation will also be central in the agenda in 2025. Below we provide an overview of the main policy developments current and upcoming which will have a significant impact on the growing European Battery industry.

2.1 Progress on the implementation of key legislative acts for the battery industry

In this context, scaling up clean technologies manufacturing in Europe (especially batteries) remains a key priority, hence the Commission is working to maintain progress on the implementation of the policy measures of the Green Deal and its industrial chapter.

The Critical Raw Materials Act

The Critical Raw Materials Act was adopted by the EU in 2024 with the aim to reinforce the EU's security of supply of critical raw materials like lithium, cobalt, or nickel. It includes targets for the development of EU capacity for the extraction, processing, and recycling of critical raw materials. In March 2025, the Commission approved the first list of strategic projects[2] under the Critical Raw Materials Act[3], comprising 47 projects in extraction, processing, recycling, and substitution of strategic raw materials. The Commission prioritised materials relevant for the battery industry with 22 projects covering lithium, 12 nickel, 10 cobalt, 7 manganese, and 11 graphite. The selected projects will benefit from accelerated permitting processes and support in access to finance.

The Net-Zero Industry Act

The Net-Zero Industry Act[4] stems from Europe's industrial ambition. It aims to develop domestic production capacity for a list of net-zero technologies by fostering a more favourable environment for manufacturing projects. The Regulation will be complemented with secondary legislation, notably to determine the non-price criteria to be applied in public procurement, auctions, and other national support schemes (e.g. incentives for consumers to purchase electric vehicles). The Commission has initiated the work on this secondary legislation, proposing a first Implementing Act pertaining to renewables auctions in March, the discussion on this proposal is ongoing with Member States representatives.

[2] European Commission Decision C(2025)1904 : https://webgate.ec.europa.eu/circabc-ewpp/d/d/workspace/SpacesStore/1958718b-21e9-40f4-9c9f-42a58dc4c5a3/file.bin
[3] Regulation (EU) 2024/1252 : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401252
[4] Regulation (EU) 2024/1735 : https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401735

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2.2 New initiatives – the Clean Industrial Deal and its sectorial plans

As mentioned above, the Commission is staying the course on decarbonisation, with a reinforced focus on reindustrialisation. This new political agenda is materialising already through the Clean Industrial Deal and will continue to be rolled-out in the next years of the mandate. Several new policy initiatives are worth highlighting to the battery community.

The Clean Industrial Deal

Drawing on the Draghi report, the Commission published in February 2025, its Clean Industrial Deal[5], a document setting out Europe's new industrial policy roadmap whereby climate objectives go hand-in-hand with industrial competitiveness. It is both a confirmation and a continuation of the European green Deal, although it focuses primarily on the decarbonisation of energy-intensive industries and the production of clean technologies. It lays out a series of measures which will be rolled-out mainly in 2025 and 2026 and will continue guiding the Commission's action for the rest of the mandate.

Amongst initiatives, the following are especially relevant for the battery industry:

Stationary Storage
The Commission acknowledges the crucial role of storage in securing cleaner, more affordable power for energy-intensive industries. In line with recently adopted legislation, it emphasises the need to simplify permitting and facilitate financing for non-fossil flexibility solutions.

Financing
Under the 2026–2027 Horizon Europe program, 600 million euros are earmarked to support ready-to-be-deployed new technologies. Furthermore, the EIB will launch a new programme, TechEU, in cooperation with private investors with the aim to bridge the financing gap for innovative solutions.

Boosting Demand for Clean Technologies
The Commission highlights that demand for clean technologies can be supported through lead markets, public procurement, and voluntary labelling schemes. Following the Net-Zero Industry Act approach, the Commission will work on incorporating non-price criteria – such as sustainability and resilience – into existing product regulations, including those covering electric vehicles.

Circularity
The Commission underlines that circularity is key in securing raw materials for the European battery value-chain. In particular, measures regarding black mass leakage will be adopted.

[5] Commission Communication: https://commission.europa.eu/document/download/9db1c5c8-9e82-467b-ab6a-905feeb4b6b0_en

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The Affordable Energy Action Plan

Together with the Clean Industrial Deal, the Commission released an Action Plan for Affordable Energy[6], looking at reducing energy prices for European consumers. It sets out a non-binding electrification KPIs to raise the share of electricity in the European energy mix from the current 23% to 32% by 2030. The Action Plan further emphasises the role of non-fossil flexibility for the future of the electricity system and underlines the importance of reducing permitting time for storage projects (especially when combined with renewable generation) and recharging infrastructure for electric vehicles. Moreover, the Action Plan includes a commitment by the Commission to assess the investment needs for the next generation of clean energy technologies, such as solid-state batteries, in order to support the achievement of the EU's climate targets.

The Automotive Action Plan

In March 2025, the Commission adopted its Industrial Action Plan for the European automotive sector[7] - the first of a series of sectorial plans under the Clean Industrial Deal. It confirms the 2025 and 2035 targets for GHG tailpipe emissions reduction for cars and vans while providing additional flexibility for car manufacturers in the 2025-2027 period. This aims at maintaining the course on electrification without penalising European manufacturers facing increased competition from non-European electric vehicles manufacturers.

The Action Plan includes a set of actions to support the competitiveness of European battery manufacturers, recognising the critical role of batteries in the electric vehicle value-chain. It notably puts forward a "Battery Booster" package summarising available funding, announces upcoming legislation to roll-out local content requirements to favour European-made battery cells and components, and reiterate the importance of circularity.

EU funding opportunities for innovation in battery technologies

In 2025, the Commission will allocate funding for the battery industry beyond the usual, with an Innovation Fund call[8] dedicated to electric vehicle battery cell manufacturing with a budget of 1 billion euros. This will be complemented by a dedicated budget of 350 million euros under Horizon Europe earmarked for Research & Innovation in the next-generation of batteries in the 2025-2027 period (it is however unclear whether this overlaps with the 600 million euros call mentioned in the Clean Industrial Deal).

[6] Action Plan: https://energy.ec.europa.eu/publications/action-plan-affordable-energy-unlocking-true-value-our-energy-union-secure-affordable-efficient-and_en

[7] Action Plan: https://transport.ec.europa.eu/document/download/89b3143e-09b6-4ae6-a826-932b90ed0816_en?filename=Communication%20-%20Action%20Plan.pdf

[8] More details on the Innovation Fund website : https://cinea.ec.europa.eu/funding-opportunities/calls-proposals/innovation-fund-2024-call-and-battery-calls_en

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2.3 Upcoming European policy initiatives

The Commission has announced several initiatives, to be developed over the next months, that should positively impact the battery industry. Key topics include stationary storage, circularity, and recharging infrastructure for electric vehicles.

New public funding framework (2025) – key initiatives expected to change the landscape for European funding (next Multiannual Financial Framework, the EU budget beyond 2027, to be proposed in Q2 or Q3 2025) and State aid funding (Clean Industrial Deal State Aid Framework, replacing the Temporary Crisis and Transition Framework, to be presented by the Commission in Q2 2025).

Chemicals Industry Package (2025) – a policy document that will recognise the strategic role of the chemicals sector as "the industry of industries" accompanied by initiatives, possibly including legislative proposals, to enhance the sector's competitiveness. This might include the belated revision of REACH (the Registration, Evaluation, Authorisation and Restriction of Chemicals with a simplification objective – and might cover PFAS (Per- and polyfluoroalkyl substances).

Industrial Decarbonisation Accelerator Act (Q4 2025) – the main legislative proposal announced in the Clean Industrial Deal, which should include an effort to roll-out sustainability and resilience criteria to boost the uptake of clean technologies made in Europe, possibly covering battery cells.

Sustainable Transport Investment Plan (Q4 2025) – an investment strategy for the decarbonisation of the European transport sector, expecting to prioritise recharging infrastructure for electric vehicles.

Electrification Action Plan (Q1 2026) – a new strategy for electrification, which should include a specific focus on the transport sector.

Grids Package (Q1 2026) – a package of proposals that should include a chapter on flexibility and storage.

Circular Economy Act (Q4 2026) – a legislative proposal aimed at boosting the supply European recycling capacities and stimulating the demand for secondary materials. Additional measures (2025-2026) should be developed for black mass specifically, to tackle the shortage of black mass for the battery value-chain in light of the obligations under the Battery Regulation as detailed in the next section.

In conclusion, the battery industry, alongside all clean technologies, remains at the top of the EU policy agenda. The Clean Industrial Deal and the measures to be proposed under its umbrella will aim to improve the competitiveness of European-made batteries. Research and Innovation is expected to play a role there, with attention from policy-makers on the needs of the next generation of batteries. Stationary storage could become more prominent in the policy framework, alongside transport applications, as the critical role of storage in the future electricity system is increasingly acknowledged and as it provides an additional market to support the growth of European-made batteries. Finally, in addition to industrial competitiveness, the renewed importance of circularity offers further guidance on priorities for the battery Research and Innovation community, which may be called to contribute to the implementation of upcoming legislative measures.

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3 The European Battery Regulation

The EU Battery Regulation [9] , was adopted on the 12th of July 2023 and is a significant legislative measure designed to address the environmental and social challenges associated with batteries. This regulation replaces the previous Batteries Directive (2006/66/EC) and introduces more stringent requirements to ensure that batteries are sustainable throughout their entire lifecycle. The battery regulation is designed so to **Support the Clean Energy Transition** by encouraging the development of a competitive and sustainable battery industry. Below the main points of the Battery regulation are highlighted.

The primary objectives of the EU Battery Regulation are to:

Promote Sustainability by ensuring that batteries placed on the EU market are sustainable, with a focus on reducing their environmental impact.
Enhance Circular Economy by facilitating the recycling and repurposing of batteries to minimize waste and promote a circular economy.
Further Enhance Safety by establishing and implementing safety standards for the production, use, and disposal of batteries.

The regulation contains the follow main provisions regarding

Sustainability Requirements
The regulation sets mandatory requirements for the sustainability of batteries and includes;

The Carbon Footprint (Article 7): Batteries must meet specific carbon footprint thresholds.
The secondary legislation for the calculation of the carbon footprint for EV batteries is nearing completion, with a draft currently available[10] . The Joint Research Centre (JRC) of the European Commission prepared the report following extensive stakeholder engagement from Q4/2021 to Q2/2023, which included two workshops and a dedicated consultation and they are currently awaiting a final decision. They have finalized the "Rules for the Calculation of the Carbon Footprint of Industrial Batteries without External Storage (CFB-IND)." This document also underwent an open public consultation. The cover pages are depicted in Figure 4.

Recycled Content (Article 8): Minimum levels of recycled materials are stated in the regulation and must be used in battery production which supports the circular economy. Secondary legislation regarding the method to calculate and verify the percentage of recycled materials will be finalised by mid 2026 and by mid 2028 the battery passport must state the content of certain recycled materials with minimum recycled content being demanded from mid 2031 and after.

Performance and Durability (Articles 9 & 10): Batteries must meet certain performance and durability criteria. Secondary legislative requirements will come in relation to this. Currently a study titled “Performance and Durability Requirements in the Batteries Regulation Part 1: General assessment and data basis”[11] prepared by the JRC is available on the JRC publications repository.

[9] Batteries Regulation 2023/1542, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 Regulation - 2023/1542 - EN - EUR-Lex

[10] Draft version of Rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV) prepared by the JRC GRB-CBF_CarbonFootprintRules-EV_June_2023.pdf

[11] JRC Publications Repository - Performance and Durability Requirements in the Batteries Regulation

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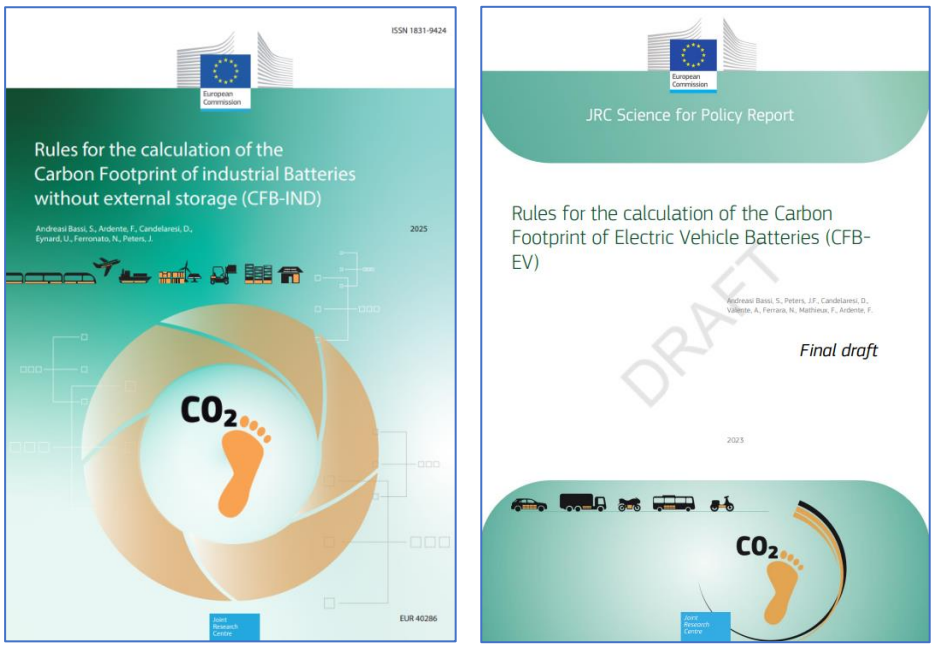

Figure 4. Cover pages for The Rules for the Calculation of the Carbon footprint industrial Batteries without external storage (CFB-IND) and the draft version of The Rules for Calculation of Carbon footprint of Electric Vehicle batteries (CFB-EV)

End-of-Life Management

The regulation emphasises the importance of proper end-of-life management for batteries:

Performance, Removability & Replaceability (Article 11) of batteries are addressed, while the repurposing of batteries is accounted for by legal provisions on second-life batteries (Article 13) encouraging the repurposing of batteries for secondary uses such as stationary energy storage. Mandatory collection rates for waste batteries (Articles 58 & 60) after their useful lifetime is set, in addition to, strict recycling efficiency and material recovery rates (Article 71) which will have the additional effect of spurring innovation in the recycling industry.

Safety and Labelling

Regulation for safety standards are set throughout the battery value chain with considerations on materials supply with responsible sourcing (chapter VII), restrictions on the use of harmful substances (Article 6) in the production of battery materials and batteries. In addition, safety is considered in the application of batteries, as addressed in the performance and durability requirements (Article 9 & 10). Batteries must comply with safety standards throughout their lifecycle.

Clear Labelling of batteries will be ensured via requirements for Information & labelling (Articles 13 & 14) and from 2027 by a digital battery passport (Articles 78 & 79) informing consumers about the battery's sustainability and safety features. Many companies are in the process of developing their battery passport for their specific products.

In conclusion the due diligence obligations (Article 48) on battery and materials producers will have a positive impact on the sourcing of raw and processed materials and components, ensuring it is ethical and sustainable. Meanwhile, the extended producer responsibility (Article 56) on economic operators putting batteries on the European market will ensure collection and recycling of batteries is carried out in an efficient and clean manner at no additional cost to the final battery owner.

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4 SET Plan and NRCG situation

The National and Regional Coordinators Group (NRCG) brings together representatives from Member States and Associated Countries (MS/ACs), drawn from national and regional authorities responsible for research, innovation, education, climate action, and energy. The group serves as a platform for exchanging best practices among Member States and regions, fostering synergies in battery research and innovation funding, and linking battery R&I at European, national, and regional levels. Over the past three years, NRCG members have been consistently informed about developments in the European R&I landscape and have progressively strengthened their engagement and collaboration compared to the early months of the BEST project. During this period (May 2022 – April 2025), the NRCG has deepened its understanding of the SET Plan and the significance and scope of cross-cutting issues in battery technology. Members have also been regularly updated on R&I funding, strategies, and initiatives across various EU and AC countries and regions.

Figure 5 New visual identity of the revised SET Plan, general logo (left), and IWG batteries new ppt template (right)

NRCG work plan

At the beginning of the period a survey was sent out to all NRCG members in order to better understand the areas of their interest and to map their expectations from the group. The outcome of this survey led to the drafting of a work plan which aim to illustrate the scope of the main activities of the NRCG in relation to the workstream of Batteries Europe and BEPA: Contribution to the SRIA, Information Exchange, International KPIs, Common reporting methodology, SET Plan reporting, leaving also space for NRCG own initiatives. For each workstream, there was an NRCG member nominated as coordinator of the task, being the main contact person and responsible for engaging the other members of the group.

At the beginning of the period, a survey was distributed to all NRCG members to better understand their areas of interest and map their expectations of the group. The results of this survey informed the drafting of a work plan aimed at defining the scope of the NRCG's main activities in relation to the workstreams of Batteries Europe and BEPA. These activities include contributions to the SRIA, information exchange, international KPIs, a common reporting methodology, and SET Plan reporting, while also allowing space for NRCG-led initiatives. For each workstream, an NRCG member was appointed as the task coordinator, serving as the main contact person and responsible for engaging other group members.

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Information Exchange

Information Exchange is the task in which NRCG members have been particularly active. The objective of this activity is to share information and facilitate dialogue among participants. In practice, NRCG members present the R&I landscape of their respective countries, followed by discussions with the rest of the group. As a result, parts of NRCG meetings were dedicated exclusively to this activity, and several ad-hoc meetings were organised specifically for this purpose. During this period, presentations were delivered by representatives from 12 countries (Portugal, Spain, Germany, Austria, Hungary, Slovakia, France, Finland, the Netherlands, Estonia, Sweden, and Slovenia) and two regions (Bavaria and Flanders).

Participation to the annual SETIS reporting exercise

The NRCG has actively participated in the annual SETIS reporting exercises. In these reports, each IWG informs the SET Plan Secretariat about the progress of R&I projects and the overall achievement of R&I targets in each technology. The NRCG contributed to the drafting of the report on behalf of the IWG, reviewing its content and suggesting national R&I projects to be featured.

Contribution to the Batteries Europe and BEPA workstreams

The NRCG also provided feedback on the R&I Roadmaps following their publication, which was utilised in drafting the BE/Batt4EU SRIA. Additionally, the NRCG reviewed and provided input on six position papers from the cross-cutting Task Forces, published in April 2024, as well as on other workstreams, such as European and International KPIs. Beyond these activities, NRCG members were occasionally invited to external meetings and events, including the Battery Plenary Session 2023 and Batteries Europe Steering Board meetings. Furthermore, some NRCG members actively participated in Working Groups and Task Forces, with some taking on leadership roles, such as co-chairing the Task Forces on Safety and Education & Skills.

World Circular Economy Forum 2024

As an ad hoc task, Batteries Europe and BEPA, under the leadership of the Flemish NRCG member and the Belgian Presidency of the European Council, organised a workshop as part of the World Circular Economy Forum 2024. Held in Brussels from 15 to 18 April 2024, the workshop aimed to explore the challenges and opportunities in battery recycling and circularity. The panel discussion featured industry representatives, the European Commission, and an academic expert from the relevant Task Forces, and was moderated by the BEPA Secretary General.

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Facilitation of the ETIPs FORUM

Beyond the scope of the NRCG, the Batteries Europe Secretariat has been coordinating the ETIPs Forum, an informal platform for collaboration between the various ETIPs. The ETIPs Forum promotes knowledge-sharing activities across the SET Plan and provides a space for coordination on areas of common interest. Through the ETIPs Forum, Batteries Europe has participated in high-level panels at the annual SET Plan Conference and other key events, such as ENLIT Europe, the European Sustainable Energy Week, and SMARTER-E. In these panels, the ETIPs Forum has presented and discussed some of its key outputs, including recommendations on the SET Plan review and joint recommendations on the draft NECPs. Other activities have included supporting workshops at the annual SET Plan Conferences, assisting in the organisation of the annual ENLIT Europe conference, and contributing to the ETIPs common report on skills, which was presented at the Renewable Energy Skills Partnership event.

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5 Battery industry developments in Europe and abroad

Batteries are a key technology for mobility and act as a major driver of product innovation across various industries. Through the EU Battery Regulation, the Critical Raw Materials Act, and the Net Zero Industry Act, Europe has established a comprehensive regulatory framework with the aim to safeguard its battery supply chain sovereignty, expand domestic production, and enhance local competitiveness. However, sustaining and advancing innovation leadership requires both consistent implementation of these regulations as well as continuous and substantial investments in the development of domestic technological expertise.

The EU's Battery cell production capacity has grown from 44 GWh/a in 2020[12] to 238 GWh/a in 2024[13]. This six-fold increase in production capacity is remarkable, but the expansion is almost exclusively due to Asian players. So far, no homegrown European battery gigafactory has successfully completed the production ramp-up. Players like LG Energy Solutions in Poland, CATL in Germany, Hungary and Spain as well as Samsung SDI and SK On in Hungary benefit from decades of manufacturing experience at scale, translating into faster and more cost-efficient ramp-up. Figure 6 shows the status quo of the European battery cell-manufacturing ecosystem as of March 2025.

Delays in ramp-up are extremely costly as materials are expensive, scrap rates are high, and capital costs are not offset by any income. This makes the ramp-up process a painful experience, especially for new market entrants. Consequently, an extremely well-developed learning culture and fast decision-making processes are essential for success. This must be complemented by excellent practical training of personnel and intensive quality control combined with appropriate data collection, processing and analysis through digital twins to maximize learning speed.

Northvolt has shown that the multitude of challenges was not compatible with the rapid growth of the company. ACC has decided to pause the development of its sites in Kaiserslautern (Germany) and Termoli (Italy) to focus initially on the ramp-up of the first gigafactory in Billy-Berclau (France). Power:Co has not yet started the ramp-up in Salzgitter (Germany), but has been able to gain valuable experience through its cooperation with Gotion High-Tech. However, the simultaneous construction of two other factories in Valencia (Spain) and St. Thomas (Canada) entails additional risks.

[12] European Court of Auditors: The EU's industrial policy on batteries – New strategic impetus needed. Special report 15-2023. 2023. Online: https://www.eca.europa.eu/ECAPublications/SR-2023-15/SR-2023-15_EN.pdf

[13] Accompanying research battery cell manufacturing: Market Analysis Update Q4/2024 – Weakening European electric vehicle market: Challenges and opportunities for the battery industry. 2024. Online: https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/publications/2024-11-BZF_Kurzinfo_Marktanalyse_Q4-ENG.pdf

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Figure 6 Status quo of the European battery cell manufacturing landscape[14]

Developing a robust battery cell manufacturing industry also requires secure access to battery materials (lithium, nickel, cobalt, graphite, etc.) and components (cathode and anode materials, separators, electrolytes). Here, Europe's situation is one of slowly improving capacity but persistent dependency. Several CAM and AAM production projects have been announced but few have even started construction. With a focus on NMC, Europe lacks competences in LFP technology, that has become the dominant technology for both mobile and stationary battery applications globally. However, it is important for European companies to ramp up production of their existing lines first to gain experience and maybe later expand to other cell technologies.

To accomplish this, European newcomers need further financial support and better plannability through predictable and stable political support for the development of the battery ecosystem. Having your own expertise in battery production can be a major asset for successful negotiations in a world that is increasingly characterised by the utilization of political power. Figure 7 shows the undiminished leading position of Chinese companies along the battery value chain. It is of particular concern that China is preparing to utilize its technological dominance politically. This is evident in the introduction of export permits for graphite products[15], as well as production technology for lithium extraction and refining and LF(M)P CAM and precursors[16].

[14] Accompanying research battery cell manufacturing: Market Analysis Update Q2/2025. in publication

[15] Mining.com: China to tighten exports of key battery material graphite. October 20, 2023. Online: https://www.mining.com/web/china-to-curb-graphite-exports/

[16] Mining.com: China flexes lithium dominance with plans for tech-export curbs. January 2, 2025. Online: https://www.mining.com/web/china-plans-export-curbs-on-battery-parts-mineral-technology/

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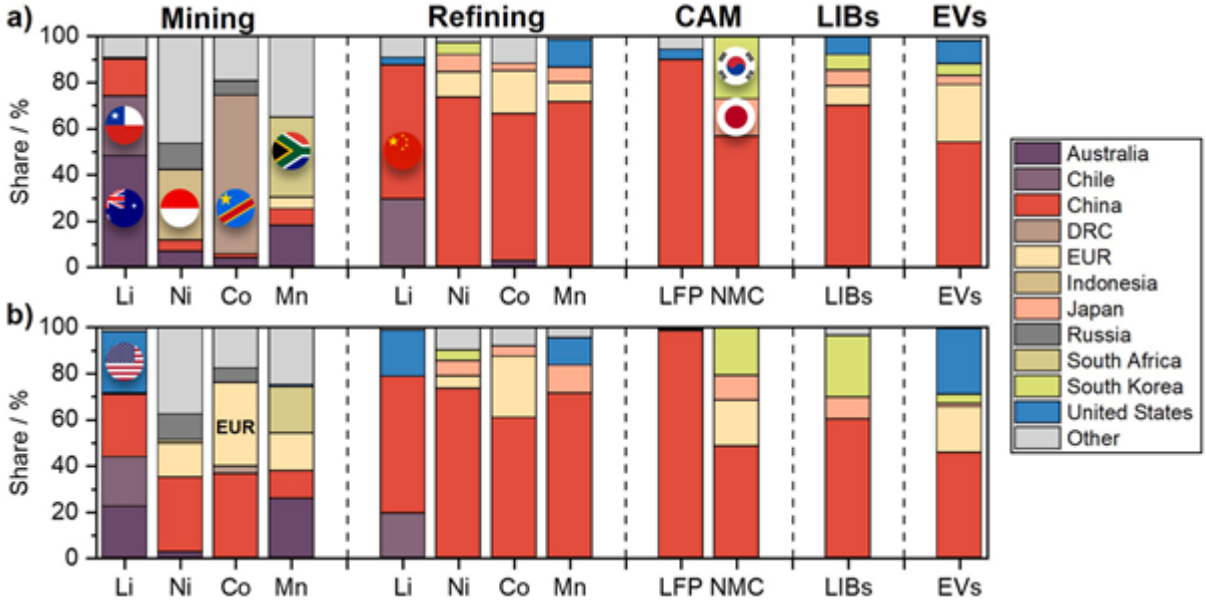

Figure 7 a) Geographical distribution and b) Ownership distribution of the LIB supply chain[17]

To better understand the global competition for dominance in the battery sector, monitoring emerging international trends offers valuable insights into policymaking and industry-academia collaboration models that drive innovation and shape research priorities in regions with advanced battery industries.[18]

Since 2020, there has been a rapid expansion of public R&D funding in battery research and development in many countries such as the U.S., Japan, Canada, and South Korea.[19] Moreover, given the scarcity of resources and rivalry of political systems, geopolitical tensions are intensifying, leading to an increasing number of protectionist measures and expansionist fantasies.

Regardless of the adopted measures, resilience remains a critical issue. However, the European battery industry continues to exhibit significant dependence on Chinese battery materials, making it vulnerable to international tensions and market fluctuations. The refining of essential raw materials, such as graphite, lithium, manganese, and cobalt, is predominantly controlled by Chinese entities.[20] Specifically, the production of cathode and anode active materials largely takes place outside of Europe. This dependency is particularly pronounced in the context of lithium iron phosphate (LFP)

[17] Tim Greitemeier, Achim Kampker, Jens Tübke, Simon Lux: China's hold on the lithium-ion battery supply chain: Prospects for competitive growth and sovereign control. Journal of Power Sources Advances. Volume 32. 2025. https://doi.org/10.1016/j.powera.2025.100173

[18] https://batterieseurope.eu/wp-content/uploads/2024/07/Overview-of-International-RDI-Battery-Funding-and-Global-Benchmarks-for-Battery-KPIs-June-2024.pdf

[19] https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cct/2024/benchmarking-international-battery-policies_2024.pdf

[20] https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/publications/2023-03-BZF_Studie_Lieferketten_DE.pdf

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batteries, where the global value chain is almost entirely controlled by Chinese companies, whose leading firms maintain a substantial competitive advantage through vertical integration.

On the other side, Europe constitutes a key destination for battery industry exports, especially for large Asian firms facing significant competitive pressure to sell abroad due to domestic overcapacity. The European market is particularly appealing given that the U.S. has imposed strong protectionist measures, such as the Inflation Reduction Act (IRA) and restrictions on imports e.g. the Uyghur Forced Labor Prevention Act (UFLPA).

A targeted strategy to diversify raw material sources and strengthen domestic production capacities is essential for ensuring long-term supply security. This requires the establishment of strategic partnerships to secure resources and mitigate risks in critical supply chains.

Despite considerable efforts in recent years, both in regulatory and technological domains, Europe continues to face a gap that must be bridged to achieve supply chain sovereignty and resilience. The time has now come for Europe to make a critical decision: either invest significantly in this sector and strive for leadership in a highly competitive global environment, or prioritize different fields, allowing other countries to further strengthen their international position in battery R&D&I. If Europe fails in establishing itself in the battery value chain, the inevitable electrification will result in the loss of technological sovereignty over the powertrain. This is associated with the significant risk of the European automotive industry, which has been very dominant up to now, losing its competitiveness. The costs of inaction will rise with each passing delay.

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6 Education and Skills

The battery sector's rapid growth demands a highly skilled workforce. By 2030, over 1.5 million jobs are estimated to emerge in Europe, requiring substantial investment in education and training. To prevent skill shortages, strategic alignment between industry needs and education across academic, vocational, and professional levels is essential for a competitive and sustainable battery value chain. Some key educational priorities for the battery sector include:

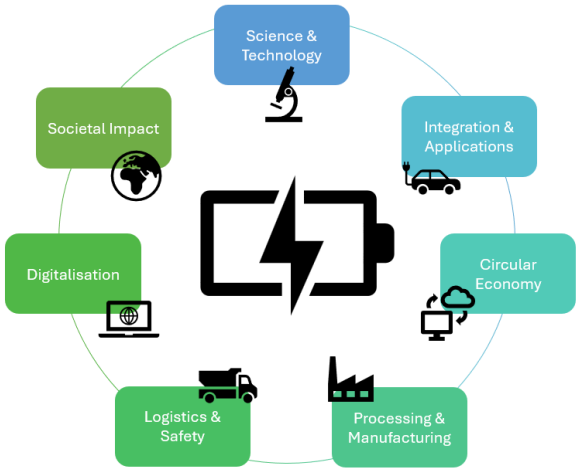

Figure 8 Main elements of battery education & training

Aligning education with technological advancements: Strong industry-academia collaboration ensures curricula remain relevant. Regularly updating educational programmes to reflect technological advancements in materials science, system design, and emerging battery technologies like solid-state batteries, AI-driven manufacturing, and digital twin applications is essential.

Interdisciplinary knowledge development: Integrating expertise across science & technology, integration & applications, circular economy, manufacturing, logistics & safety, digitalisation, and societal impact is key.

Expanding specialised master's programmes and cross-disciplinary research will build diverse skills for battery innovation as shown in Figure 8.

Strengthening R&D opportunities: Supporting innovation through scholarships, internships, and industry collaborations to maintain a strong R&D ecosystem and Europe's leadership in battery technology. Continued EU funding for PhD and postdoctoral research is vital.

Embedding sustainability in education and training: Integrate sustainability into education by focusing on battery recycling, life cycle assessment, environmental impact assessment, circular economy principles, responsible sourcing, and sustainable R&D and design practices, to prepare professionals for the clean energy transition.

Enhancing hands-on training: Provide practical experience in cell production, assembly, handling, transport, installation, maintenance, safety, and recycling through industry-led vocational training (VET) in state-of-the-art facilities.

Industry-academia collaboration: Expand joint research, internships, and apprenticeships to enhance industry-relevant training. Promoting gender balance will help build a diverse and resilient workforce.

Upskilling and reskilling initiatives: Equip workers transitioning from internal combustion engine (ICE) industries and related sectors, with targeted training in manufacturing, quality control, design-to-cost principles, and system integration. Large-scale workforce transition programmes are also needed to facilitate job mobility.

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Addressing trainer shortages: Develop train-the-trainer programmes that combine technical and pedagogical expertise, ensuring high-quality instruction and attracting more professionals into the sector through a unified European certification framework.

Standardisation of education and certification: Establish standardised curricula at bachelor's and master's levels and a European certification framework to ensure consistent skill levels, workforce mobility, and skill recognition.

Flexible curriculum development: Promote modular curricula in academic institutions and training centers that can be quickly updated to align with emerging technologies and evolving industry needs.

Investment in training infrastructure: Increase investment in advanced training facilities, pilot production lines, and virtual labs to bridge the gap between theory and practice.

Public awareness and policy engagement: Increase awareness of battery technologies and career opportunities through outreach, school programmes, awareness campaigns and engagement with policymakers to shape effective education and training policies.

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7 SSH Considerations for the Battery Sector

Social Sciences and Humanities (SSH) plays an important role in for the adoption of battery technology by addressing the broader societal, ethical, and economic dimensions. SSH ensures that advancements in battery research align with social well-being, environmental sustainability, and economic inclusivity. Unlike ESG (Environmental, Social and Governance), which primarily focuses on corporate sustainability performance, SSH provides a broader societal and academic framework to evaluate how the technology integrates into daily life and impacts different communities.

SSH encompasses various disciplines, including sociology, political science, economics, education, human geography, law, philosophy, and ethics. Key themes relevant to battery R&I include ethics and human rights, policy and governance, consumer behaviour and market adoption, and economic and social equity, ensuring fair access and sustainable supply chains.

For policymakers and regional authorities, SSH research provides valuable insights to ensure technological advancements in batteries are **ethically responsible** and aligned with **societal needs**. It helps safeguard that **battery production and recycling** meet national and European environmental goals, integrates SSH considerations into innovation funding, and supports workforce development by **identifying emerging job roles and skills**. Additionally, SSH research enhances public trust in battery technologies through **education and policy measures**, promotes **inclusive energy systems** by addressing **social barriers to adoption**, and informs strategies to **integrate battery industries into regional economies** while ensuring **fair labor practices** and **community benefits**.

Particularly relevant SSH topics include; **Social Life Cycle Assessment (S-LCA)** which evaluates the **social risks of battery production**, such as **labour rights and working conditions** in raw material extraction. For example, a study on vanadium redox flow and lithium-ion batteries highlighted how supply chain risks disproportionately affect workers in raw material extraction.

Public perception and social acceptance research examines how the design and location of battery storage systems **influence community support**. Studies have shown that large-scale battery storage systems often face resistance due to their visual impact and community concerns, emphasising the need for better engagement.

Ethical mining and supply chain governance investigates labour conditions in cobalt and lithium mining to ensure **responsible sourcing**. Ethnographic research on cobalt mining in Congo, for instance, has revealed severe human rights violations, leading to calls for stricter regulations.

Other critical SSH areas include **digitalisation and cybersecurity**, which assess the risks of battery data management and the role of cybersecurity in battery technology. Research has shown that while digitalising battery supply chains improves efficiency, it also raises concerns about **data privacy and infrastructure security**.

Finally, **policy and governance impact on battery deployment** explores how different national policies affect battery adoption and energy storage solutions. Comparative studies of Battery Energy Storage System (BESS) policies have demonstrated that variations in subsidies, incentives, and grid regulations significantly influence deployment rates across countries.

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8 Acknowledgements

Firstly, we at the Batteries Europe secretariat wish to thank the European Commission for having the foresight to create Batteries Europe ETIP and for supporting this secretariat with two mandates. We have seen that both DG RTD and DG Energy have supported Batteries Europe ETIP, which along with Battery 2030+, has created much of the materials and roadmaps which have been corner stones of the Strategic Research and Innovation Agendas for Europe. In addition, members of the European Commission have always made the time and effort to present at our meetings, something we are deeply grateful for.

Furthermore, we welcome the support of a new CSA call, which will have a slightly different focus while still facilitating continuation of many key aspects currently dealt with in Batteries Europe ETIP and Battery 2030+. BEPA will shortly take up the task of running the Working Groups and the Task Forces and we are highly confident that they will do an excellent job in this.

We would also like to thank the JRC for their strong support and open communication with Batteries Europe ETIP and the members of the NRCG who create time out of their busy schedules to dedicate towards contribution to the ETIP activity and facilitating battery technology development in their country / region.

A heartfelt thanks goes out to our 800 stakeholders. Preparing the Roadmaps, SRIAs and KPIs has provided a valuable and rewarding opportunity for us to work with so many talented, capable researchers, innovators and managers at all ages and career stages from both academia and industry. It is impossible to name and acknowledge all 800 of you individually here however please know your contributions to Batteries Europe's written documents and to the meetings have been meaningful.

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