

A hand holding a battery, with glowing blue lines swirling around it, symbolizing energy and connectivity.

DELIVERABLE 4.2
RECOMMENDATIONS FOR
EUROPEAN CURRICULA
BATTERY 2030+ CSA3

BATTERY
2030+

At the heart of a connected green society

Document Classification

Deliverable Number & Title	D4.2 - Recommendations for European Curricula
Work Package	WP4 – European curricula in future battery technologies
Author(s)	KIT/CELEST- Emma Argutyan, Christian Punckt
Delivery due date	2025-08-31
Dissemination Level	Public (PU)

Document History

Internal review	2025-08-22	All partners
Contributions	2025-07-28	KIT/CELEST- Stephan Hensel
Validation	2025-08-29	Project Coordinators P1 UPPSALA – Patrik Johansson patrik.johansson@kemi.uu.se



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant number No. 101104022.

Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

TABLE OF CONTENTS

1. INTRODUCTION.....	4
1.1. METHODOLOGY	4
1.2. OBJECTIVES	5
2. RECOMMENDATIONS FOR EUROPEAN CURRICULA	7
2.1. CORE VS ELECTIVE.....	9
2.2. APPLIED MASTER’S PROGRAMMES	9
2.3. ADVANCED RESEARCH PROGRAMS (PHD & POSTDOC)	10
2.4. FOUNDATION LEVEL (VOCATIONAL/TECHNICAL).....	11
2.5. EXECUTIVE COURSES FOR INDUSTRY PROFESSIONALS	11
3. DIGITALISATION & EDUCATION PLATFORMS	12
3.1. DATA AND ONTOLOGY	12
3.2. ACCREDITED MODULES WITH DUAL-TRACK.....	12
3.3. MICRO-CREDENTIALS.....	13
4. IMPLEMENTATION.....	14
5. CONCLUSION	15
Wallenberg Initiative Materials Science for Sustainability, Sweden	20

ANNEXES

Annex 1: Overview of Existing EU Programmes Categorized by Education Level and Battery2030+ Research Areas	16
Annex 2: Results of the Mentimeter Survey from the BATTERY2030+ Münster 2025 Annual Conference	20

1. INTRODUCTION

As Europe positions itself at the forefront of the energy transition, battery technologies have become a strategic sector essential to achieving the EU's climate neutrality, digital transformation, and industrial competitiveness goals. Yet, existing educational structures are not keeping pace with the sector's rapid technological and industrial changes.

The earlier associated deliverable D4.1 provided a comprehensive mapping of ongoing education and training initiatives across Europe. It revealed a highly fragmented landscape marked by limited coordination weak visibility of existing programs, and major differences in how content is developed, delivered and recognised across countries.

Critical challenges identified in D4.1 include:

- Lack of visibility and discoverability of existing training programs, especially for prospective learners and employers
- Limited coordination and absence of a common European framework for battery education and training
- Weak involvement of industrial actors in curriculum design and delivery
- Fragmentation across disciplines, sectors and education levels
- Insufficient access to practical, hands-on training across all stages
- Gaps in interoperability and recognition of training content across national systems
- Uneven coverage of the full battery research, development, and production chain
- Insufficient integration of transversal competencies such as sustainability, digitalisation and standardisation
- Underdeveloped digital and modular teaching formats such as VR/AR and online micro-credentials.

Building on the insights from D4.1, this deliverable, D4.2, presents a set of recommendations that addresses the challenges listed above. It aims to improve coherence, interoperability, and strategic alignment across European battery education efforts. We propose the development of a harmonised yet flexible curriculum *framework* that can support both academic research and the industrial workforce. The recommendations are designed to enhance comparability, quality, and cross-border collaboration, offering guidance to universities, national authorities, and EU stakeholders alike.

In doing so, deliverable D4.2 supports the goal of building a well-coordinated European research and education ecosystem for future battery technologies, aligned with international, national, and regional strategies.

1.1. METHODOLOGY

To support the development of targeted and evidence-based recommendations for battery-related curricula, we applied a multi-layered methodology combining European landscape analysis (as outlined in D4.1), stakeholder consultation, and international benchmarking.

We took the current European education needs and training landscape – based on institutional inputs from Battery 2030+ partners and national stakeholders – as a starting point. This mapping revealed a number of structural challenges: a geographical imbalance in programme availability (with Northern and Western Europe being more active than Southern and Eastern regions), fragmentation of curricula, and the absence of common certification standards. A particular gap was observed in practical and vocational training, especially in areas critical to industrial deployment, such as battery up-scaling, manufacturing, and recycling.¹

In parallel, we conducted a benchmarking exercise focusing on international reference cases. Insights from the United States highlight a broad and digitally enhanced educational offer, including virtual reality-based training modules; however, alignment with industry needs remains limited². In contrast, China demonstrates a more integrated and coordinated approach, with strong industry-academia collaboration and national-level support for dual education models that blend academic and hands-on learning³.

Complementing these analyses, we collected qualitative input through interactive polling tools (e.g., Menti.com), including during the Battery 2030+ Annual Conference in Münster (2025). These stakeholder perspectives helped validate the findings and further shape the recommendations presented in the following chapters.

1.2. OBJECTIVES

This deliverable contributes to achieving Objective O-4 of the Battery 2030+ initiative. Its primary goal is to translate research results from Battery 2030+ projects and roadmap themes into structured and transferable curricula for Master's and PhD education. Rather than developing entirely new programmes, we propose a framework that enables the sharing and alignment of existing curricula across EU Member States. This framework is intended to be adopted not only by academic institutions but also in close collaboration with industry stakeholders.

A key aim is to address the pressing skills gap across the European battery value chain. In particular, the framework aims to support battery manufacturers – especially cell producers – by ensuring that educational offerings reflect both current and emerging workforce needs.

Battery education in Europe must serve two complementary purposes. On one hand, academic research drives fundamental progress in areas such as materials chemistry, physics and science, electrochemistry, and cell testing and manufacturing. On the other, the battery industry requires a highly qualified workforce to support large-scale production, quality assurance, process automation, and end-of-life management. To meet both demands, European curricula must bridge the gap between

¹ D4.1 „Update on education/training needs“, p. 15

² <https://pubs.acs.org/doi/10.1021/acs.chemrev.4c00980>

³ Based on online search and ChatGPT

research and application. This includes providing layered educational pathways – from vocational training to doctoral education – underpinned by strong collaboration between academia and industry.

2. RECOMMENDATIONS FOR EUROPEAN CURRICULA

We aim not to define a completely new curriculum but rather to synthesise and align existing battery education initiatives and frameworks into a cohesive, flexible, and adaptable structure that can be applied across Europe. Building on the comprehensive mapping presented in Deliverable D4.1, which examined a wide range of university-level and vocational training programmes across EU Member States, this section reflects the fragmented yet evolving landscape of current educational offers.

Despite the emergence of promising models, such as the Nordic Five Tech joint Master's (and PhD) programme⁴ in battery technology, and interdisciplinary initiatives like i-MESC (Materials for Energy Storage and Conversion)⁵, there is a clear need for greater curricular coordination, standardisation of certification, and enhanced focus on vocational and hands-on training - especially in critical areas like battery up-scaling, manufacturing, and recycling⁶.

While recent years have seen significant progress, including the launch of interdisciplinary Master's programmes, new B2030+ MOOCs on Standards and Ontology,⁷ and lifelong learning initiatives, marked disparities remain across regions. There are particular shortcomings in practical, hands-on training, the alignment of curricula with industrial needs, and the harmonisation of certification standards. Nevertheless, the landscape is rich with best practices, such as the Battery Coast⁸, an application-oriented battery engineering education and emerging digital learning format.

These findings are consistent with the broader analysis presented in the BEPA/Batteries Europe position paper on skills and education⁹ (2024), which stresses the importance of aligning education and training with industrial demand and fostering transnational cooperation to close the EU-wide skills gap in battery technologies. Furthermore, consultation with Battery 2030+ stakeholders, including via live feedback sessions (e.g., at the 2025 Münster conference) revealed several recurring themes and strategic priorities for shaping future educational initiatives in the battery sector (consult Annex 2 for more details). Respondents identified critical curriculum gaps, notably the need to incorporate advanced topics such as smart battery functionalities—sensing, self-healing, and real-time monitoring—as well as sustainable and recyclable battery design. While many participants emphasized that existing content remains valuable, they also called for more forward-looking modules and highlighted the underrepresentation of practical and vocational training. Future curricula should prioritise areas such as process knowledge, manufacturability, upscaling, and environmentally responsible materials, alongside digital integration and lifecycle management including second-life applications and recycling. There was strong consensus on the inclusion of non-scientific professional skills such as project management, budgeting, innovation, and business strategy, with additional

⁴ <https://www.nordicfivetech.org>

⁵ An Erasmus Mundus joint Master co-funded by the EC and coordinated by the University of Picardie Jules Verne from 2023-2029: <https://i-mesc.eu/>

⁶ Deliverable D4.1, Sections 2.1–2.5, pp: 8-13.

⁷ <https://statics.teams.cdn.office.net/evergreen-assets/safelinks/2/atp-safelinks.html>

⁸ <https://battery-coast.uia.no/>

⁹ [BEPA/Batteries Europe, 2024 Position Paper on Cross-Cutting Topics](#)

emphasis on foresight, sustainability, and collaboration with industrial partners. Stakeholders overwhelmingly supported a joint governance model for curriculum development, led by academia but strongly informed by industry, and advocated for more flexible structures that support cross-sectoral mobility and career development.

Battery 2030+ is expected to play a central role as mediator, connector, and potential certifier of programmes, facilitating knowledge exchange and policy alignment. Effective knowledge transfer mechanisms, such as structured training linked to research outputs and centralized databases, were seen as vital to bridging research and education. Suggestions for curriculum development varied by educational level, including fast-track reskilling for vocational workers, hybrid bachelor and master programmes that integrate industrial mobility, and advanced doctoral training that supports innovation, entrepreneurship, and spin-offs. Finally, to enhance cooperation and standardisation, joint summer schools and early-stage sustainability alignment were recommended, along with improved digital infrastructure to link related initiatives such as the Digital Battery Passport and GAIA-X.

In this context, Deliverable D4.2 does not attempt to create a prescriptive one-size-fits-all curriculum but instead proposes to consider a flexible and adaptable EU wide framework, capable of accommodating national diversity while promoting core competencies, mobility, and mutual recognition of qualifications. This aligns with the strategic objective of Battery 2030+ to establish a well-coordinated European research and education initiative, embedded within national and regional programmes, and capable of attracting the next generation of skilled researchers, engineers, and innovators to the battery sector¹⁰.

In addition, we promote targeted “train-the-trainer” programmes for vocational instructors, ensuring that educators are equipped with the latest teaching methods, technical content, and safety standards in battery-related training.

By drawing on these examples and the identified gaps, this deliverable lays the groundwork for a pan-European curriculum framework - one that supports regional adaptation while fostering greater coherence, mobility, and excellence in battery education across Europe.

Namely:

- The creation of an EU-wide Battery Education Platform listing accredited programs, micro-credentials, and training modules
- The alignment of national programs with frameworks such as Battery 2030+, the European Battery Alliance, i-MESC, and the SAE/InnoEnergy Battery Academy
- The advocacy for standardisation of learning outcomes and certification
- The provision examples of existing joint degrees and modular learning packages (with stackable credits) to support learner mobility and serve as good practices for developing future initiatives.

¹⁰ [Battery 2030+ Roadmap 2023](#), p.22

2.1. CORE VS ELECTIVE

To ensure both consistency and interoperability across EU Member States while allowing room for local adaptation, the deliverable distinguishes between core and elective elements. The core curriculum should universally include foundational topics such as digitalisation, battery recycling, and data and ontology management¹¹. These subjects are essential for equipping learners to operate effectively in a rapidly evolving and data-driven battery research environment¹². They lay the groundwork for curriculum modularity, platform-level recognition, and long-term interoperability across institutions and national systems¹³.

In contrast, elective elements may cover emerging and specialised areas such as smart functionalities, allowing institutions to tailor their offerings to local strengths or research niches while still contributing to a cohesive European educational landscape¹⁴. This structure reflects the underlying dual demand shaping battery education: the need for research-based innovation on the one hand, and industrial application and workforce readiness on the other¹⁵. The involvement of industrial actors is therefore critical — not only in shaping curriculum content, but also in providing meaningful practical training environments. Embedding this dual focus ensures that graduates are not only equipped to advance Europe's scientific leadership but also ready to contribute to its strategic autonomy in battery manufacturing, deployment, and end-of-life management¹⁶.

2.2. APPLIED MASTER'S PROGRAMMES

This deliverable does not aim to propose a new curriculum for advanced Master's- or PhD programmes. Instead, it presents and analyses existing educational offerings across the European Union, European Economic Area based on the Battery 2030+ research areas. (Please check ANNEX 1 for the full list). The goal is coherent and interconnected European battery education landscape, enabling dual implementation models, that meet both scientific innovation and industrial skills needs based on feedback collected from industry stakeholders (elaborated in the methodology).

Research Area	Educational Focus	Skills Developed
Materials Acceleration Platform (MAP) & Battery Interface Genome (BIG)	Interdisciplinary education in electrochemistry, modelling, materials discovery, and digitalisation	Data-driven experimentation, interface diagnostics, life-cycle design, collaboration with industry
Battery Functionality: Sensing & Self-Healing	Training in battery management systems, functional diagnostics, and safety integration	Smart diagnostics, degradation detection, control systems, system-level engineering

¹¹ BATTERY2030+ Deliverable D4.1, Section 2.1 & 2.3

¹² BATTERY2030+ Deliverable D4.1, Section 2.1 & 2.3

¹³ [BATTERY2030+ Roadmap v1.3](#), pp.68-70

¹⁴ Ibid. pp. 36-38

¹⁵ [BEPA/Batteries Europe, 2024 Position Paper on Cross-Cutting Topics](#)

¹⁶ [EIT InnoEnergy / EBA Academy Framework](#)

Cross-Cutting Areas: Raw Materials, Recycling & Circularity	Sustainable sourcing, eco-design, recycling, second-life use, LCA, machine learning	Circular economy principles, systems-level sustainability, interdisciplinary environmental expertise
Data & Ontology Tools	Data science, electrochemistry, predictive modelling, ontology development	Battery health monitoring, materials discovery acceleration, cross-platform data sharing
Manufacturing & Digital Systems	Automation, robotics, digital twins, factory-level process innovation	Industry 4.0 readiness, predictive maintenance, quality assurance, smart manufacturing systems

2.3. ADVANCED RESEARCH PROGRAMS (PHD & POSTDOC)

Existing advanced research programmes already support the Battery 2030+ objectives through structured doctoral and postdoctoral training in electrochemical energy storage, including lithium-ion and post-lithium batteries.

The European doctoral programme DESTINY (MSCA COFUND, 2020-2026, renewed as DESTINY 2 for 2026-2031), coordinated by CNRS (France), involves 40 research institutes and 13 companies across 13 European countries in the training of 94 PhD candidates in strategic battery research areas identified in alignment with Battery 2030+ priorities.

Similar national or bi-national initiatives include the Graduate School on Electrochemical Energy Storage (GS-EES), IQST Graduate School @QuantumBW in Germany, Sweden's SEC, BASE, WISE and COMPEL; CIC energiGUNE in Spain; the split PhD format between Vrije Universiteit Brussel (VUB) & JRC Petten (Netherlands); and Italy's, Politecnico di Torino, Politecnico di Milano, and CNR offering postdoc and PhD fellowships,

Additional noteworthy initiatives include the Helmholtz Institute Ulm (HIU) and MEET Battery Research Centre in Germany, which conduct interdisciplinary battery research within doctoral frameworks; and DTU Energy in Denmark, contributing PhD positions in solid-state batteries and battery energy storage systems through Nordic MSCA networks like PREDICTOR and Nordic5Tech.

These programmes combine scientific depth with interdisciplinary education, offering block courses, summer schools, and workshops focused on transferable skills such as communication, project management, and good scientific practice. International collaboration, in certain cases, is actively promoted through mandatory research stays abroad. Ongoing research into quantum materials and interfaces contributes to BATTERY2030+ priorities in advanced material functionalities and interfacial phenomena, which are critical for solid-state batteries and sensor integration. The flexible and cross-disciplinary nature of these programmes fosters innovation at the intersection of materials science, system design, and data-driven research—key pillars for building integrated battery research platforms.

2.4. FOUNDATION LEVEL (VOCATIONAL/TECHNICAL)

There is currently no fully established EU-wide certified “train-the-trainer” module specifically for battery education. While national and regional programs exist, certifications remain fragmented and vary in quality across Europe.

However, initiatives such as Battery 2030+, the European Battery Alliance, i-MESC and EIT RawMaterials/InnoEnergy are actively working to close this gap. Their efforts support the development of harmonized training standards aligned with the EU’s industrial and Green Deal strategies to build a skilled, sustainable battery workforce. Annex 1 several examples of already running initiatives.

2.5. EXECUTIVE COURSES FOR INDUSTRY PROFESSIONALS

A range of executive education programmes is emerging across Europe to support industry professionals working in or transitioning into the battery sector. These courses typically focus on strategic areas such as digitalisation, sustainability, energy management, and innovation. Many programmes offer modular or part-time formats to accommodate working professionals and often combine online instruction with in-person sessions or capstone projects¹⁷. While some programmes are specifically designed for the energy and battery domains, others provide broader competencies that are increasingly critical for executive roles in the battery value chain—particularly in areas like digital transformation, policy, and sustainable business strategy.

¹⁷ A final, practice-oriented project that integrates and applies knowledge gained throughout a program, often addressing a real-world problem or research question

3. DIGITALISATION & EDUCATION PLATFORMS

Harmonising battery-related education across Europe requires more than aligning curricular content - it depends on building a shared digital infrastructure that enables interoperability and consistent knowledge exchange. A central example is the Battery Knowledge Base¹⁸, developed collaboratively within the Battery 2030+ community and anchored in the BattINFO ontology¹⁹. Hosted as a machine-readable, open platform it supports the standardisation of terms, metadata, and domain-specific knowledge across disciplines and institutions. Karlsruhe Institute of Technology (KIT) and SINTEF play a key role in coordinating ontology development and digital infrastructures to support this effort. By structuring data in ways that are interoperable and searchable across labs and learning platforms, the Battery Knowledge Base lays the foundation for scalable and FAIR²⁰-compliant education and training. While some educational programmes are beginning to integrate ontology use and semantic tools, wider adoption is needed to ensure micro-credentials, course metadata, and content structures can be reused and recognised across Europe. A truly harmonised educational space for battery research and innovation must be underpinned by such shared digital frameworks — not just shared curricula.

To enhance accessibility and educator quality, this deliverable advocates for the development and dissemination of Massive Open Online Courses (MOOCs) on both battery fundamentals and specialised topics, ensuring wide accessibility for students, professionals, and other stakeholders across Europe and beyond.

3.1. DATA AND ONTOLOGY

A growing number of educational programmes across Europe are beginning to integrate data-driven methods and ontology-based frameworks to support next-generation battery research and innovation. These initiatives promote system-level thinking, predictive performance modelling, and structured approaches to handling battery-related data. Training elements often include digitalisation, diagnostics, and lifecycle analysis, preparing students to work with industrial data environments and apply advanced modelling techniques. By contributing to standardised vocabularies, metadata structures, and interoperable data practices, such programmes align with Battery 2030+ objectives to foster FAIR data principles, accelerate materials discovery, and enable smart functionalities across the battery value chain.

3.2. ACCREDITED MODULES WITH DUAL-TRACK

Several Europe-wide initiatives are actively shaping a coordinated and future-proof battery skills ecosystem. The European Battery Alliance Academy (EBAA)²¹, led by EIT InnoEnergy, aims to upskill thousands of workers across Europe in key areas such as cell design, production, and sustainability, with a focus on scalable, industry-relevant training. Complementing this, the ALBATTs Skills Card²², developed under the Automotive Skills Alliance, offers competence-based training modules aligned

¹⁸ https://battery.knowledge-graph.eu/wiki/Main_Page

¹⁹ <https://github.com/BIG-MAP/BattINFO>

²⁰ Findable, Accessible, Interoperable & Reusable

²¹ <https://www.eba250.com/>

²² <https://www.project-albatts.eu/en/skillscards>

with the European Qualifications Framework (EQF), supporting workforce development across the entire battery value chain. Within the Battery 2030+ initiative, efforts to foster open and modular learning include the development of Massive Open Online Courses (MOOCs). The first course, focusing on battery data²³, is already available, and a second on battery recycling is currently under development. Together, these initiatives exemplify a dual-track approach that connects research-led education with hands-on vocational training, bridging academic and industrial priorities across Europe.

3.3. MICRO-CREDENTIALS

Although micro-credential offerings in the battery sector are still emerging, initiatives such as the European Battery Business Club (EBBC)²⁴ represent an important step toward building the digital infrastructure and standards necessary for scalable skills development. These initiatives primarily target mid-career professionals seeking flexible, modular training in high-demand battery domains. Designed as stackable micro-learning units, they fit within broader digital education frameworks and support accreditation pathways aligned with common European standards. Importantly, content development often involves close collaboration between research organizations and industry partners to ensure alignment with real-world skills needs across the battery value chain. Coordinating such efforts with wider European education and training programs could accelerate the recognition, portability, and interoperability of micro-credentials across member states, thereby strengthening the capacity to deliver agile and industry-relevant battery education at scale.

²³ [GitHub - jsimonclark/five-star-battery-data: A repository containing resources related to the Five-Star Battery Data MOOC](https://github.com/jsimonclark/five-star-battery-data)

²⁴ <https://www.batterybusinessclub.com/>

4. IMPLEMENTATION

To translate the insights from this mapping exercise into action, we propose a multi-phase implementation strategy aligned with the Battery 2030+ vision. The goal is to connect existing educational initiatives across Europe, support their expansion, and guide the creation of new interdisciplinary modules that address gaps identified in this deliverable.

- Create a centralised **European Battery Curriculum Platform**. This digital platform under BATTERY2030+ umbrella should facilitate credit transferability, curricular harmonisation, and alignment with the Bologna Process. It should be underpinned by a shared ontology and interoperable metadata standards, ensuring transparency and comparability across programmes and Member States.
- Establish a **European Curriculum Taskforce**, with the potential to be supported by future coordination and support actions (CSA). We express readiness to lead or contribute to this effort, ensuring that expertise from both academia and industry is reflected in the process.
- Set-up a “**generational bridge**” within the battery education ecosystem, enabling the structured transfer of knowledge from elderly and/or retired experts to early-career researchers and engineers, preserving institutional memory and fostering intergenerational learning.
- **Establish dedicated European Education Hubs and Skills Centres**, promoted and supported by the European Commission. Serving as regional focal points, these centres would provide training, upskilling, and reskilling across the battery value chain, from production workers to senior managers. Working closely with industry, they would align content with real-world needs, especially for the growing gigafactory workforce, and offer modular programmes, vocational courses, placements, and lifelong learning in manufacturing, quality control, automation, safety, recycling, and digitalisation.

5. CONCLUSION

Deliverable D4.2 highlights the urgent need to transform research insights and industrial requirements into harmonised, future-oriented battery education curricula across Europe. Despite numerous promising initiatives in recent years, the educational landscape remains fragmented, with many programmes lacking EU-wide visibility and operating in isolation. This hinders knowledge exchange, standardisation, and strategic impact.

The growing importance of transversal professional skills, such as project management and intellectual property (IP) literacy, as integral components of battery-related education, is also acknowledged. These competencies are essential for equipping graduates to thrive in complex innovation ecosystems and contribute effectively to both academic and industrial environments.

In response, Deliverable D4.2 offers concrete recommendations to guide the development of coherent, layered, and interoperable educational framework. These proposals are closely aligned with the goals of the BATTERY2030+ initiative and the broader European Skills Agenda²⁵, laying the groundwork for a more integrated and responsive skills ecosystem in the battery domain.

²⁵https://employment-social-affairs.ec.europa.eu/policies-and-activities/skills-and-qualifications/european-skills-agenda_en

ANNEXES

Annex 1: Overview of Existing EU Programmes Categorized by Education Level and Battery2030+ Research Areas

Materials Acceleration Platform (MAP) & Battery Interface Genome (BIG)

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>Materials for Energy Storage and Conversion (i-MESC)</u> Consortium based: France (coordinator), Spain, Slovenia & Poland	- Interdisciplinary master programme - Focus on battery materials & energy conversion - Supported by ALISTORE ERI, CIC Energigune, and RS2E - Academic and industry-led training - Thesis placements at Bosch, Umicore, Renault, Solvay, Saft	- Materials Discovery & Energy Conversion - Industry Collaboration & Technology Transfer
<u>M.Sc. Battery Technology and Energy Storage</u> Uppsala University (Sweden)	- Led by Ångström Advanced Battery Centre - Tracks: Materials Chemistry & Cell/System Engineering - Focus on materials, cell design, digitalisation, diagnostics, lifecycle analysis, recycling, industrial application	- Materials Discovery & Interface Chemistry - Data-driven Diagnostics & Digital Twins - Lifecycle & Recycling Integration
<u>M.Sc. Battery Systems Engineering</u> RWTH Aachen (Germany) (Starting Autumn 2025)	- Full battery value chain - Modelling, manufacturing, testing, degradation, recycling - Industrial placements and thesis on recycling or societal aspects - Lectures, research labs, internships	- Battery Functionality & Durability - Degradation Mechanisms - Recycling & Circular Economy - Industrial Scale Manufacturing
<u>Professional Master in Battery Ecodesign</u> University of Bologna (Italy)	- Sustainable materials & production - Life Cycle Assessment (LCA), ecodesign, digital twin, machine learning - Regulatory frameworks and recycling integration - Vocational focus & safe-by-design principles	- Sustainable Materials & Production - Safe-by-Design & Regulatory Compliance - Digital Twins & Machine Learning - Circularity & Recycling

Battery Functionality: Sensing and Self-healing

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
---------	-----------------	---------------------------------------

<u>EIT InnoEnergy Master's in Energy Storage</u> Partner universities: KU Leuven, UPC Barcelona, Grenoble INP	- Focus on advanced battery technologies, BMS, smart grid integration - Mobility scheme across institutions - Innovation & entrepreneurship training	- Digitalisation & Diagnostics - Smart Battery Functionalities - System-level Sensing & Control
<u>M.Sc. Energy Storage</u> TU Clausthal (Germany)	- Covers electrochemical & thermal storage - Focus on safety, modelling, control - Includes lab and system-level work	- Functional System Integration - Thermal Monitoring & Reliability - Safety & Self-Healing Research
<u>Erasmus Mundus Joint Master Degree in Smart Energy (SME)</u> Consortium based: Sweden, France, Italy and Spain	- Interdisciplinary joint degree - Focus on smart grid, energy storage, systems integration - Combines electrical engineering with innovation & entrepreneurship	- Networked Battery Functionalities - BMS Integration - Smart Grid & Digital Infrastructure Interaction
<u>Professional Master in Battery Ecodesign</u> University of Bologna, Italy	- Sustainable materials, production processes, LCA, ecodesign - Digital twin, machine learning, regulatory frameworks - Vocational orientation, safe-by-design emphasis	- Sustainable Materials & Production - Safe-by-Design & Regulatory Compliance - Digital Twins & Machine Learning - Circularity & Recycling

Cross-cutting research areas, raw materials, recycling and circularity

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>MBATT – Master in Battery Technologies</u> Universidad Politécnica de Valencia (Spain)	- International programme covering the full battery value chain - Focus on raw materials, electrochemistry, BMS, modelling, recycling, and EV/grid integration - Industry-led modules and hands-on training in manufacturing, reuse, and material recovery	- Resource Efficiency & Circularity - Cross-Cutting Integration (from materials to application) - Industrial Processes & Battery Lifecycle
<u>Professional Master in Battery Ecodesign –</u> University of Bologna, Italy	- Combines sustainable materials, LCA, ecodesign, digital twins, ML, regulatory frameworks - Emphasizes safe-by-design and recycling chain integration - Linked to Battery2030+ activities	- Safe-by-Design & Sustainability - Digitalisation & Predictive Diagnostics - Circular Economy & System-Level Intelligence

Data & ontology

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>M.Sc. in Battery Technology and Energy Storage</u> Uppsala University (Sweden)	- Led by Ångström Advanced Battery Centre - Two tracks: Materials Chemistry and Cell/System Engineering - Includes training in digitalisation, diagnostics, lifecycle analysis, modelling, and advanced electrochemistry	- Strong focus on digitalisation and system-level diagnostics - Prepares students in battery modelling, predictive performance assessment, and industrial data integration - Contributes to ontology development through structured system-level training
<u>M.Sc. Battery Systems Engineering</u> RWTH Aachen University (Germany)	- Launching autumn 2025 - Covers entire battery value chain: modelling, manufacturing, testing, degradation, recycling - Combines lectures, labs, industrial internships, and thesis work on recycling or societal energy aspects	- Focus on modelling and degradation diagnostics - Builds practical understanding of data acquisition and testing workflows - Prepares students to integrate diagnostics into battery management systems and circular design tools

Manufacturing and digital systems

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>MSc in Digital Manufacturing for Innovative Ecosystems</u> (EIT Manufacturing) Partner institutions : Grenoble INP, SUPSI, UCD, Ecole Centrale de Nantes	- Training in cyber-physical systems, modelling & simulation, virtual prototyping, and digital monitoring - Focus on digital twins for manufacturing	- Strong alignment with digital twin technologies in battery production - Supports innovation in cyber-physical systems and smart manufacturing environments - Equips students for data-driven process optimisation
<u>M.Sc. in Sustainable Battery Production Engineering (dual)</u> SRH University, Germany	- Dual (work-study) format with direct industry collaboration - Focus on production engineering, sensor technologies, quality control, lifecycle management, and data analytics - Practical skills for battery factories	- Direct relevance to smart battery production systems - Bridges academic and industrial training in modern battery manufacturing - Emphasizes digital integration and workforce readiness
<u>M.Sc. Battery Technology</u> University of Bayreuth (Germany)	- Research-oriented, engineering-focused - Taught in German - Covers energy storage systems,	- Supports holistic understanding of battery production and system integration - Addresses scalable, sustainable

	production processes, and recycling - Includes systems engineering approach	manufacturing practices - Emphasizes interdisciplinary, production-relevant research
--	--	---

Advanced Research Programs (PhD & Postdoc)

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
Graduate School on Electrochemical Energy Storage (GS-EES) , Germany	- Offers a structured doctoral training program - Provides interdisciplinary education through block courses, annual summer schools, workshops on scientific and professional skills	- Battery technologies such as lithium-ion, post-lithium batteries, and fuel cells. - Good scientific practice
DESTINY & DESTINY2 – consortium-based Marie Skłodowska-Curie Cofund PhD Programme	- Training of 94 PhD students between 2020 and 2031 - DESTINY 2 Focuses on 5 main areas: • Post Li-Ion technologies • High-power devices • Battery manufacturing and recycling • New materials and electrolytes • Advanced methods (characterization and testing).	- Modelling and Artificial Intelligence for Accelerated Materials Discovery - Advanced (electrochemical) Analysis Techniques (diffraction, spectroscopy) including operando characterization, battery monitoring, smart battery functionalities, crystal chemistry, safety, technology transfer and prototyping. - Manufacturability and recycling
German IQST Graduate School @ Quantum BW , Germany	Graduate School supporting PhD projects between basic research and application in quantum science and technology	Advanced material functionalities and interfacial phenomena
Hector Fellow Academy , Germany	An interdisciplinary fellowship program offering mentorship and collaborative research opportunities for doctoral and postdoctoral researchers	Innovation at the intersection of materials science, data-driven research, and system design
Helmholtz Institute Ulm (HIU) , Germany	Structured doctoral training in lithium-ion and post-lithium battery technologies with state-of-the-art facilities for synthesis, cell assembly, advanced characterization, and modelling	-Next-gen battery materials and sustainable chemistries -Digitalisation and automation in production and quality control -Research on ageing, safety, and lifetime prediction

		-Recycling and circular economy integration -Cross-disciplinary use of materials science, electrochemistry, and AI -Support for scalable manufacturing technologies
MEET Battery Centre, Germany	Doctoral training in lithium-ion and next-generation battery technologies with interdisciplinary research combining materials science, electrochemistry, and engineering	-Innovations in cell design and manufacturing processes -Battery ageing, safety, and performance optimization -Sustainable battery technologies and recycling -Support for scalable manufacturing aligned with gigafactory needs
Swedish Electrochemical Centre (SEC)	Multidisciplinary PhD training on electrochemical energy storage technologies with a strong industry partnership for real-world applicability and technology transfer	-Next-generation battery materials and architecture -Advanced cell design and manufacturing optimisation -Automation and digitalisation of production and testing -Sustainability, recycling, and circular economy integration -Battery ageing, safety, and performance improvement
Batteries Sweden (BASE), Uppsala University	Interdisciplinary doctoral training focused on lithium-ion and beyond lithium battery technologies, offering collaboration between academia, industry, and research institutes in Sweden	-Next-gen battery materials and architectures -Advanced manufacturing automation and digitalization -Sustainable lifecycle and recycling -Battery safety, ageing, and performance -Digital tools and AI for design and diagnostics
Wallenberg Initiative Materials Science for Sustainability, Sweden	A major Swedish research initiative spanning chemistry, physics, and materials engineering with advanced characterization, modelling, and digital-assisted materials discovery	-Sustainable materials for next-gen battery chemistries -Implementation of circular economy principles in materials design -Use of AI and digital tools for fast-tracked materials discovery -Infrastructure support for scalable and sustainable battery manufacturing

<u>Competence and Excellence for the Electrification of the Transport system (Compel), Uppsala University, Chalmers University of Technology and Lund University</u>	Strengthens Sweden's position in battery research and electrification of the transport sector by providing critical expertise and research results to industry	-Materials research relevant to battery technology and power electronics -Integration of batteries with power electronics in the grid and in vehicles -Safety of energy storage in batteries and hydrogen
CICenergiGUNE, Spain	Research centre exclusively dedicated to electrochemical energy storage, hosts PhD and postdoctoral researchers, usually under collaborative agreements	-Focus on both lithium-ion and next-generation battery technologies. -Advanced materials research, cell prototyping, battery performance testing, modelling, and cycling stability studies
Vrije Universiteit Brussel (VUB), Belgium & Joint Research Centre (JRC) Petten, Netherlands	A collaborative doctoral arrangement where PhD candidates spend time at both VUB and JRC Petten, often combining academic rigor with policy-oriented research facilities	Battery lifetime, performance optimisation, safety, and sustainability, aligning with standards, testing, and life cycle analysis
Politecnico di Torino, Italy	PhD programmes in Electro-chemical and chemical energy storage -Collaboration with industry partners and research institutes for applied projects	Long-duration energy storage (LDES) systems -Multi-scale and multi-physics modelling (atomistic up to continuum level simulations) -Advanced characterization techniques to deepen current understanding of battery lifetime -Integration of storage in power systems
Politecnico di Milano, Italy	The PhD programme aims to prepare professionals with a strong scientific foundation in power systems, electricity markets, and the application of energy storage	- Research into lithium-ion, solid-state, and next-generation battery Advanced materials & architectures -Automation & digitalisation -Safety, ageing & performance -Sustainability & circular economy
National Research Council of Italy (CNR), Italy	PhD projects commonly focus on battery materials development, electrode and electrolyte optimization, battery cell design, and performance characterization	-Extensive research in materials science, electrochemistry, and energy storage

		- Battery safety, ageing mechanisms, and performance enhancement - Sustainable materials and recycling -Digitalisation and AI tools
DTU Energy, Denmark	-Focus on electrochemical energy storage -Strong collaboration with industry partners and international research networks - Access to advanced experimental and modelling facilities	-Next-gen battery materials and architectures -Automation and digitalisation of production and testing -Sustainable lifecycle and recycling -Battery safety, ageing, and performance -Digital tools and AI for design and diagnostics -Scalable manufacturing technologies
PREDICTOR , Marie Sklodowska-Curie Cofund PhD Programme	-Focuses on predictive modelling and simulation for battery materials and cells -Provides interdisciplinary training combining materials science, electrochemistry, data science, and machine learning	- Digital twins and predictive models for battery performance and ageing -Automation and digitalisation through advanced simulations -Enhances understanding of battery degradation and safety - Integrates AI and data-driven approaches for accelerated materials discovery
Nordic5Tech : DTU (Denmark), Chalmers University of Technology (Sweden), Aalto University (Finland), NTNU (Norway), and Tampere University (Finland)	-Promotes joint doctoral education, researcher mobility, and collaborative projects across member universities. -Supports interdisciplinary research including energy storage, materials science, and sustainable technologies. -Enables PhD students to access resources, supervision, and facilities across the Nordic region	-Next-generation battery materials and technologies -Digitalisation and automation in battery design and manufacturing - Sustainable approaches including recycling and circular economy -Advances understanding of battery ageing, safety, and performance -Use of AI and data-driven methods for battery innovation

Foundation Level (Vocational/Technical)

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
European Battery Alliance (EBA) Nordic5Tech	-Promotes skills development across the battery value chain supports workforce training initiatives. -Some pilot projects focus on curricula, but formal trainer	- Battery Management Systems - Manufacturability - Materials acceleration / Interface research - Recyclability & circular design - Smart safety functionalities

	certification is still under development	Standardisation
<u>EIT RawMaterials Training</u>	-Offers practical courses and certifications -Focuses on industry-relevant skills	Battery materials, recycling, and sustainability
<u>Battena, EDLB, H-TASE, Electro'mob, FODUBLIVE (CMAs programmes related to energy storage, France)</u>	- Educational programmes ranging from secondary school to doctoral studies, including life-long learning (main focus: technical education). -Mainly regional focus, curricula tailored in line with regional industrial needs.	From the synthesis of materials to recycling processes Manufacturability

Executive Courses for industry professionals

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>Mastering Digital Twins</u> (Fraunhofer IPK, Germany)	- Modular, online certificate programme - Focus on full digital twin lifecycle - Designed for professionals in engineering/manufacturing	High – supports battery digitalisation, production, lifecycle management
<u>Digital Twins: Current State and Future Potentials</u> (Aalto University, Finland)	-Short, on-demand masterclass -Open to professionals and graduate students -Focus on networked and industrial twins	Battery diagnostics and digital manufacturing
<u>MBA Renewables</u> Berlin University of Applied Sciences and Technology & the Renewables Academy (RENAC)	-Part-time, online MBA -Focus on energy policy, management, sustainability -Optional site visits	Sustainability leadership in battery value chain
<u>Global MBA – Green Energy and Sustainable Businesses</u> (Bologna Business School, Italy)	-Full-time international MBA -Clean energy innovation, sustainability strategy	Strategic/business-level understanding of battery sector
<u>Batteries MBA, Ireland</u>	-CPD-certified 12-week part-time online designed to equip professionals with both technical expertise and business strategy knowledge across the full battery value chain	From materials and cell manufacturing to systems integration and market analysis
<u>Digital Twins-Executive Master</u> Consortium based: Spain, France & Hungary	-Blended sessions -Focus on digital twins and capstone projects	Battery production and diagnostics

Micro-credentials

Program	Main Highlights	BATTERY2030+ Research Areas Alignment
<u>EIT InnoEnergy Academy</u>	Offers practical online courses and certificate programs in energy storage and battery technologies. Strong industry focus.	MESC, Battery Functionality, Sustainability

European Battery Business Club , Fraunhofer Academy, Germany	Short courses and professional development on batteries and energy storage technologies. Combines research and practical training.	MESC, Full MAP, Battery Interface Genome
EIT RawMaterials Training	Practical courses and certifications on battery materials, recycling, and sustainability. Focus on industry-relevant skills.	MESC, Sustainability, Recycling
Ecole de la Batterie (EDBL) , France	Includes and offer of life-long learning and ‘train the trainer’ courses. Some courses are available online. Strong industrial focus (coordinated by Verkor).	Manufacturability Automation Recycling

Annex 2: Mentimeter Survey on (new) curricula collected at the BATTERY2030+ Münster 2025 Annual Conference

Category	Key Insights
Career level & field of work	Diverse respondents incl. Master's, PhD, postdocs, senior researchers and industry representatives
Battery value chain focus	Respondents work on battery materials, pack manufacturing, testing & safety, Modelling and simulation, digitalisation, application, 2dn life & recycling, mining and processing
Any parts of curricula that are no longer needed	All respondents indicated a negative response
Curriculum Gaps	Core topics like materials, design, and applications remain key, but future curricula should also cover smart cells with sensing, self-healing, and monitoring. Sustainability is now included, but sensing needs renewed focus
Critical battery R&D focus in future curricula	Materials science and simulation remain vital. Process and design improvements. Smart batteries and novel materials (e.g., Mg, Li-metal) are still underexplored, yet essential for lifetime performance, safety, and second-life use
Professional skills	Majority support inclusion of non-scientific skills, i.e. project management, negotiation skills, economics, funding acquisition
Who shall be in charge of (new) curricula delivery?	Preference for hybrid academia–industry models
BATTERY2030+ role in curricula delivery	Seen as mediator, coordinator, and curriculum integrator

Ideas on curricula on foundation level ("blue collar")	Re-train skilled blue-collar workers from related fields with targeted, practical programs (e.g., mechatronics) focused on advancing technical know-how. Offer fast-track requalification in energy storage for those with industry-scale production experience
Ideas for curricula for applied bachelor and master programmes	Improve electrochemistry in chemistry courses, emphasizing process complexity, quality, cleanliness, and discipline. Support industrial mobility through hybrid internships and thesis projects linking academia and industry, fostering wider networks. Focus on battery engineering and materials chemistry
Ideas for curricula for advanced research programmes (PhD and Postdoctoral level)	Offer applied hard skills training (instruments, techniques) and promote industrial mobility. Create a platform using PhD project results to foster start-ups and new business models focused on services and leasing, inspired by examples like HILTI's shift from product sales to service