

DELIVERABLE 4.1
UPDATE ON EDUCATION /
TRAINING NEEDS
BATTERY 2030+ CSA3

BATTERY
2030+

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1 INTRODUCTION

As Europe strives to lead in battery research and innovation, it is crucial to address the evolving educational needs for higher education in this sector. Within Battery 2030+, we have analysed the current educational landscape and engaged with partners and young researchers in the Battery 2030+ community to identify key gaps and opportunities. While Battery 2030+ actively contributed in writing the BEPA/Batteries Europe position paper on skills and education¹, which provides a broad perspective on education across all levels, this deliverable focuses specifically on higher education. Our goal is to help shaping the next generation of scientists, engineers, and professionals who will drive battery materials, battery production, recycling, and innovation etc. in Europe.

The Battery 2030+ initiative aims to invent the sustainable batteries of the future, supporting Europe's transition to a climate-neutral society and to integrate cutting-edge research themes into education, ensuring that students and researchers acquire the skills necessary for future advancements in the field. Key topics include smart functionalities for batteries, advanced modelling systems, and sustainable recycling processes. These themes align with the broader objectives of sustainability, efficiency, and technological leadership in Europe. By embedding these concepts into higher education curricula, we can better prepare future experts to tackle the challenges of next-generation batteries and contribute to Europe's strategic autonomy in the energy transition.

In deliverable D 4.1 we report on educational projects in the area of batteries in order to identify “empty” spaces in the didactical process. This document is an update of the state-of-the-art of education reported in D3.2 in Battery 2030PLUS (CSA2) and it is a collaboration with the Battery 2030+ projects (see www.battery2030.eu for details). The deliverable focusses on new ideas that have emerged over the last three years. It takes into account the main current education activities at major European universities, ongoing Erasmus Mundus, Leonardo, and Marie Skłodowska-Curie Actions, and in addition the educational activities within ALISTORE-ERI, EIT InnoEnergy and EIT Raw materials.

¹ <https://batterieseurope.eu/results/position-papers-on-cross-cutting-topics-2024/position-papers-on-cross-cutting-topics-2/>

1.1 Methodology

We have followed two approaches in parallel to gather the information contained in this report. For the first approach, the contributing organizations (UU, FZJ, KIT, NIC, POL, WWU, CNR, AIT, BEP) provided information about the most recent educational activities in their regions. This information was compiled and is presented for Northern, Southern, Western and Eastern Europe separately. The second approach relies on surveys conducted among the partners of the Battery 2030+ large-scale research initiative as well as among the participants of key battery events, e.g., at the Battery 2030+ annual conference in Grenoble in May 2024. The outcome of these two approaches is presented in the following chapters.

Based on the monitoring of the educational landscape and the outcome of our surveys, we arrive at educational needs and gaps. These are presented in the third part of the results section. Building on these needs, we will in the upcoming deliverable D4.2 (New Curricula) present suggestions for education and training programs of the future.

2 THE EDUCATIONAL BATTERY ECOSYSTEM IN EUROPE

Europe nowadays hosts a variety of educational programs dedicated to battery technology, ranging from academic courses to vocational training.

University-Level Education

- **Master's Programs:** Many European universities offer specialized master's programs covering battery materials, electrochemistry, and energy storage systems. These programs aim to equip graduates with a strong theoretical and practical understanding of battery science and engineering.
- **Ph.D. & Research Training:** The demand for highly skilled researchers in the battery-related fields is growing, particularly in materials development, battery production, and system integration. Many European universities and research institutions provide doctoral training and postdoctoral opportunities in collaboration with industry.

Industry-Oriented and Vocational Training

- **Lifelong Learning and Upskilling:** As the battery sector evolves, professionals require continuous education. Vocational programs and industry-driven training initiatives help employees update their knowledge in areas such as manufacturing, recycling, and safety.
- **Technical & Vocational Education:** Specialized training programs focus on hands-on skills for battery production, maintenances, and quality control. These are particularly relevant for technicians and production staff in gigafactories.

Pan-European Educational Initiatives

- **Albatts and Erasmus+ programs:** The Albatts project, part of the Erasmus+ “Blueprint” initiative, is shaping educational models tailored to battery value chain. These initiatives aim to integrate battery-related competencies into national education systems across Europe.
- **The SAE/InnoEnergy Battery Academy²,** a collaboration between SAE International and EIT InnoEnergy, offers over 400 hours of training on battery technology. Covering the full battery lifecycle—materials, manufacturing, applications, and recycling—the program targets engineers, technicians, and academics. Structured into five modules, it provides specialized knowledge in EV batteries, battery management systems, cybersecurity, and energy storage, addressing industry needs.
- **Collaborative Research and Training Networks:** European battery research initiatives (e.g., Battery 2030+) have spurred the creation of new interdisciplinary education programs, bridging research, industry, and policy needs.

² <https://www.sae.org/learn/professional-development/sae-innoenergy-battery-academy>

To provide a detailed overview of battery-related education in Europe, we have categorized programs by region: Northern, Southern, Western, and Eastern Europe. This approach allows us to highlight regional trends, emerging initiatives, and specific challenges in battery education across different parts of the continent.

Rather than listing every educational program, we focus on notable developments and key trends. With the rise of electromobility and energy storage, nearly every European country—along with the UK—has introduced battery-related training at the university or vocational level. Additionally, many battery education projects operate across national borders, fostering international collaboration and competition. Some initiatives address specific societal challenges, such as workforce development for the gigafactory sector or the sustainability aspects of battery recycling.^{3,4}

The following sections examine how these trends manifest in different European regions, highlighting both established programs and new initiatives shaping the future of battery education.

2.1 Education and training in Northern Europe

Over the past three years, **battery-related education and training programs in Northern Europe** have expanded significantly, driven by increased collaboration across Denmark, Finland, Norway, and Sweden. Universities, industry partners, and governments have recognized the urgent need for a skilled workforce, leading to the establishment of **new academic programs, vocational training initiatives, and interdisciplinary research collaborations**.

A major development has been the **Nordic Five Tech joint master's program on batteries**, launched at fall 2024. This program, involving Chalmers University of Technology, KTH Royal Institute of Technology, Aalto University, NTNU, and DTU, allows students to complete their first year at their home university and their second year, including a master's thesis, at a partner institution. Closely aligned with the Battery 2030+ initiative, this program fosters **academic mobility, interdisciplinary training, and industry collaboration** to prepare graduates for leadership roles in battery research and manufacturing. Additionally, Nordic Five Tech has launched a **graduate school for PhD students**, further strengthening advanced training in battery technology.⁵

European-wide collaboration is also growing. **EIT RawMaterials**⁶ has funded several **lifelong learning courses** in partnership with the University of Oulu, Uppsala University, and NTNU.⁷ Another example is the EMJM (Erasmus Mundus Joint Master) **i-MESC (Materials for Energy Storage and Conversion)**, a master's consortium involving universities in France, Spain, Slovenia, and Poland, as well as international partners in the US and Australia. The new i-MESC curriculum includes digital twin-based educational games in Virtual Reality (VR) and in Mixed Reality (MR) to complement battery production and characterisation in the lab, and the development of a novel metaverse, as a complement to

³ <https://automotive-skills-alliance.eu/about-us/>

⁴ <https://batterieseurope.eu/results/position-papers-on-cross-cutting-topics-2024/position-papers-on-cross-cutting-topics-2/>

⁵ <https://www.nordicfivetech.org/>

⁶ <https://eitrawmaterials.eu/education-skills>

⁷ <https://www.battvalue.com/>

physical interactions between students located around Europe. The doctoral programme on batteries and energy storage DESTINY coordinated by ALISTORE-ERI has been renewed for 2025-2030 and will fund 42 PhD projects. These programs ensure that students gain exposure to **multiple institutions and industrial contexts**, supporting the broader Battery 2030+ vision of a unified and skilled European research community.

Sweden remains the strongest player in battery research and education. Uppsala University is the only institution offering a **dedicated master's program in Battery Technology and Energy Storage**,⁸ while KTH, Chalmers, and Lund University focus on **electrochemistry, materials chemistry, and system implementation**. Other universities, such as Luleå Technical University and Linköping University, have expanded their curricula to cover different aspects of the battery value chain. Recognizing the need for a larger battery-skilled workforce, the Swedish government has **funded an increase in student enrollments at Uppsala, Chalmers, and Lund University**, with additional research funding to support new academic staff. In 2022, the government also commissioned eight universities to **develop short courses for engineers and professionals**, including a **MOOC on battery basics**, which has already attracted over 300 participants.⁹ For 2024-2025, additional funding has been allocated specifically for battery-related education.

Finland has also significantly expanded its battery education programs to support its growing battery industry. The **South East Finland Battery Cluster Project**¹⁰ is mapping **regional training needs** and developing a **multi-level training model** in cooperation with vocational schools, applied sciences universities, and research institutions. Universities such as Aalto, Oulu, and Turku have long provided courses in battery technology and continue to **expand their portfolios**.^{11,12,13} The University of Oulu offers training specifically to support the **growing gigafactory sector**, while VAMK University of Applied Sciences in Vaasa launched a **battery industry training program** in 2023 to meet the increasing demand for skilled workers.¹⁴

Denmark has focused on **data management and modeling** as key areas for battery education. DTU has developed a **MOOC on research data management**, aimed at improving battery-related data handling skills in both scientific and industrial contexts. Additionally, a **PhD summer school on battery modeling**, scheduled for 2025, will provide advanced training in computational and experimental approaches to battery research. These initiatives align with broader European efforts to integrate **AI, digitalization, and advanced analytics** into battery development and production.

⁸ <https://battery-coast.uia.no/>

⁹ Batteries: Powering a Mobile World - Open Courses

¹⁰ <https://www.lut.fi/en/projects/southeast-finland-battery-cluster-education-project>

¹¹ One example of a course at Aalto 2025: <https://www.aalto.fi/en/programs/sustainable-battery-design>

¹² One example of a course at Oulu: <https://joy oulu.fi/en/training-needs-battery-sector>

¹³ One example of a course at Turku University: <https://www.utu.fi/en/university/faculty-of-technology/mechanical-and-materials-engineering/research/battery-materials-and-technologies>

¹⁴ <https://www.vamk.fi/en/ajankohtaista/vamks-new-battery-training-responds-to-the-battery-industrys-growing-needs>

Norway's battery education is led by **NTNU** and the **University of Oslo**, both of which have long-established research and teaching programs in battery materials and systems. NTNU has grouped battery-related courses across bachelor's, master's, and PhD levels, and is actively involved in the **Nordic Five Tech master's program**. The University of Stavanger is **building new research capacity**, leading to the development of new courses in battery technology. A particularly industry-focused initiative is **Battery Coast**, hosted by the University of Agder, which connects academia and industry along the full battery value chain.¹⁵ The university's location near **Morrow's gigafactory** ensures that students gain practical experience in battery production and system integration.

Overall, **Northern Europe is setting a benchmark for battery education** through a mix of **government-backed university programs, industry collaboration, and EU-funded training initiatives**. While Sweden and Finland are **scaling up programs** to meet the growing demand for skilled workers, Denmark and Norway are focusing on **specialized training in data management, modeling, and industry-academic collaboration**. The main challenges ahead include **bridging vocational and university education, ensuring standardized training for gigafactory roles, and expanding education in the Baltic region**. However, with increasing investment and collaboration, Northern Europe is well-positioned to supply the skilled workforce needed for the future of battery technology.

2.2 Education and training in Southern Europe

Over the past few years, **Southern Europe**, particularly **Italy, Spain, and Portugal**, have made significant progress in developing battery education and research programs. This growth is driven by a combination of **academic initiatives, collaborative research projects, and industry partnerships**, aimed at strengthening the region's role in the European battery value chain. Universities, research institutions, and industries are working together to equip students and professionals with the necessary skills for the evolving battery and energy storage sector.

Italy has a well-structured and diverse educational landscape for battery technology, spanning multiple universities and degree programs. The **University of Bologna** offers courses in **battery modelling, pack design, and innovative storage technologies** as part of its Advanced Automotive Engineering and Environmental Sciences programs. It also provides a Master's in Low Carbon Technologies and Sustainable Chemistry, with training in battery characterization and advanced materials. The **University of Milano-Bicocca** includes electrochemical energy storage in its **Materials Science and Nanotechnology program**, covering reaction mechanisms in lithium-ion batteries and supercapacitors. **Sapienza University of Rome** integrates battery storage modules within its **Industrial Chemistry master's program**, while the **University of Pavia** covers a broad range of battery technologies, from **lead-acid to post-lithium systems**, in its Chemistry and Engineering program. **Politecnico di Torino** plays a leading role in Italy's battery education by offering specialized courses in **battery assembly, management systems, and next-generation battery technologies** for mobility. The university collaborates with **EIT InnoEnergy** and hosts some of **Battery2030+ Excellence Seminars**, exposing students to cutting-edge European research.

Spain is also expanding its battery education programs. The **University of the Basque Country** and **CIC energiGUNE** are partner institutions of **EMJM i-MESC**. **University of Valencia, ITE and Power**

¹⁵ <https://battery-coast.uia.no/>

Electronics also host the **MBATT** (Master of Continuing Education in Battery Technologies) online master more focused in battery production, integration, battery production, management and testing. The **University of Barcelona** offers a **Master's in Electrochemistry: Science and Technology**, developed in collaboration with nine Spanish universities. This program covers **fundamental electrochemistry and battery applications**, reflecting the increasing demand for specialists in energy storage. Spain is also a host country of the **EBA250 Battery Academy**. Meanwhile, **Portugal's University of Évora** is an active member of the **Batpower Battery Cluster**, working to position the country as a hub for battery research and innovation.

Research institutions across Southern Europe are also driving battery education forward. Italy hosts **ELMO-LION**, an **EU-funded PhD course and summer school** focusing on lithium-ion battery fabrication, characterization, and market trends. Students benefit from online lectures, project work on industrial challenges, and venture-creation training. The **Flash Battery company** in Italy collaborates with academia to provide hands-on experience, recently hosting students from the **European Master's in Energy Storage**. In Portugal, the **Battery Cluster Portugal** participated in the **Batteries Teachers and Trainers Forum (BaTT Forum)**, an event bringing together educators and industry representatives to discuss workforce training and sustainability in the battery sector. In Spain, the **Battery Plat initiative** fosters collaboration among research institutions, industry, and policymakers to advance battery technologies and strengthen national expertise in energy storage.

Industry collaborations play a crucial role in expanding training opportunities in Southern Europe. Flash Battery actively engages in **career outreach programs** to connect students with potential employers in the energy storage sector. In Spain and Portugal, **Glencore, FCC Ámbito, and Iberdrola** have partnered to develop **lithium-ion battery recycling solutions**, addressing the need for sustainable end-of-life management. Additionally, the **European Battery Alliance Academy** provides structured training programs to prepare new talent for careers in battery production and development.

Despite significant advancements, some challenges remain. In Portugal, the **joint venture between Galp and Northvolt** to build a **battery-grade lithium refinery** has faced delays due to project complexity and grant funding uncertainties. Originally set to begin operations in 2026, the project timeline has been extended, highlighting the difficulties in scaling up battery-related infrastructure.

Overall, **Southern Europe is rapidly enhancing its battery education and research landscape**. Universities are expanding their curricula, industry collaborations are strengthening practical training, and international partnerships are fostering a competitive and skilled workforce. These efforts aim to establish the region as a key player in Europe's energy transition, with a growing emphasis on sustainable production and recycling. While challenges remain in funding and scaling industrial initiatives, continued investment in education and workforce development will be crucial to ensuring long-term success in the battery sector.

2.3 Education and Training in Western Europe

In recent years, **Central Europe**, encompassing **France, Germany, the Netherlands, Belgium** and the **United Kingdom**, has made significant strides in advancing battery education and training programs. This progress is driven by national initiatives, robust academic-industry collaborations, and a focus on interdisciplinary curricula to meet the evolving demands of the energy storage sector.

In **France**, educational projects on batteries have been gaining momentum, driven by the prioritisation of the sector in **France 2030**¹⁶, a €54 billion investment plan aimed at transforming key industries through innovation and research. The various batteries-related educational and training initiatives foster a strong synergy with industrial stakeholders, a shift towards a mission-oriented organisation of the curriculum, and an increasing integration of digital pedagogical tools.

Initiatives funded under the scheme “**Compétences et Métiers d’Avenir**” (“**Skills and the jobs of the future**”, **CMA**)¹⁷, range from secondary school to doctoral studies and include life-long learning. They promote stronger connections between educational institutions and industrial actors at the regional and national levels. The **CMAs BATTENA, Ecole de la Batterie (EDBL), Electro’mob, FODUBLIVE, and H-TASE** are enabling the creation of new **Bachelors of Technology**, for example at the **University of Toulouse**¹⁸, that provide future assistant engineers with an understanding of the **whole battery value chain**, from extraction and mass-production to end-of-life and recycling. Existing **Masters’ courses are being reinforced: hands-on training** on batteries has been introduced at the **University of Pau** (Battena). This includes assembly, charge and discharge cycles, physico-chemical and morphological analysis during and after cycling. At the **École Mines-Télécom (IMT) of Lille**, the engineering course ‘data-driven industrial excellence’ will include modules on ‘Industrial data and AI for industrial performance management, quality control, and continuous improvement applied to battery production’ (Electro’mob).

Funded under the France 2030 scheme “**ExcellencES**”, the **E-SENSE** project coordinated by the **University of Picardie Jules Verne** collocates battery learning and research within an energy-transition-themed graduate school that brings together STEM and social sciences. In terms of digitalisation, **EDBL**, coordinated by Verkor, has a rich offer of distance-learning courses¹⁹, while **H-TASE (coordinated by Paris-Saclay)** will use immersive videos from the premises of industrial partners to promote battery-related careers.

In **Germany**, the educational landscape for battery technology is equally dynamic. The **University of Bayreuth** offers an English-taught Master's program in **Battery Materials and Technology**, addressing central issues of energy storage with an interdisciplinary approach. Similarly, the **Technical University of Braunschweig** provides a Bachelor's degree in **Battery and Hydrogen Technology**, targeting individuals interested in renewable energy and climate protection. For professionals seeking advanced knowledge, the **HECTOR School at the Karlsruhe Institute of Technology (KIT)** offers intensive short courses on the latest insights and innovations in battery technology. Moreover, the **RWTH International Academy** in Aachen provides a research-oriented Master's program in **Battery Systems Engineering**, covering all aspects of the battery value chain, from modelling to recycling processes. These programs are designed to equip students and professionals with the skills necessary to excel in the evolving energy storage sector. Additionally, the **European Battery Business Club (EBBC)**,²⁰ hosted

¹⁶ <https://www.economie.gouv.fr/france-2030>

¹⁷

<https://www.info.gouv.fr/upload/media/content/0001/12/d9ccd4776f4b7fea9e958022891a30482c9df076.pdf>

¹⁸ <https://www.univ-tlse3.fr/decouvrir-nos-diplomes/licence-professionnelle-parcours-stockage-electrochimique-de-lenergie-see>

¹⁹ <https://ecoledelabatterie.fr/nos-formations/>

²⁰ <https://www.batterybusinessclub.com/>

by Fraunhofer IFAM, provides online battery training programs with industry insights. It delivers an online training program integrating the latest industry knowledge with flexible microlearning elements, catering to professionals looking to enhance their expertise.

In **Switzerland and Austria**, battery-related education and training programs are expanding to meet the growing demand for expertise in energy storage and sustainable energy systems. Several universities and research institutions offer specialized degree programs, industry collaborations, and vocational training to equip students and professionals with the skills required for the battery sector.

In Switzerland, **ETH Zurich** provides one of the most comprehensive programs through its **Master in Energy Science and Technology (MEST)**, which allows students to specialize in energy storage and battery systems. **Empa**, the Swiss Federal Laboratories for Materials Science and Technology, collaborates with ETH Zurich and offers **advanced courses** on charge transport and lithium-ion battery materials. It also co-organizes the **Swiss Battery Days**, fostering industry-academic collaboration. The **Swiss Battery Technology Center (SBTC)** at the Bern University of Applied Sciences (BFH) operates the country's largest battery test laboratory, supporting applied research in energy storage.

In Austria, leading universities have developed specialized programs in battery and energy storage. **Graz University of Technology (TU Graz)** offers a Master's in **Technical Chemistry**, where students can focus on battery technology and fuel cells. The **University of Innsbruck**, through its Institute of Physical Chemistry, conducts research on cost-effective and sustainable battery technologies. Several universities of applied sciences have introduced targeted master's programs. The **University of Applied Sciences Upper Austria (FH OÖ)** offers a Master's in Sustainable Energy Systems, which includes courses on hydrogen and battery systems. The **Carinthia University of Applied Sciences (FH Kärnten)** provides a Master's in Electrical Energy & Mobility Systems, focusing on battery technology, energy storage, and mobility logistics. The **Vorarlberg University of Applied Sciences (FHV)** offers a Master's in Sustainable Energy Systems, emphasizing energy transition and storage solutions.

Both Switzerland and Austria emphasize interdisciplinary approaches, hands-on training, and close collaboration between academia, industry, and research institutions. With strong research-driven programs, vocational training opportunities, and connections to global battery initiatives, these countries are positioning themselves as key players in Europe's battery education landscape, ensuring a skilled workforce to drive innovation in energy storage and sustainable technologies.

In the **Netherlands** many projects, internships, bachelor assignments and master assignments are performed within the field of energy storage and conversion, for example at the **University of Twente**. They also offer different courses in Master programs on different aspects of batteries, ranging from basic electrochemical knowledge to energy conversion in a broader perspective. **TU Delft** also offers a range of courses in batteries, among them a MOOC for Battery Management Systems (BMS) and Pack Design. Furthermore, they have Pathfinder, an EU program for junior scientists. The **University of Gronin** offers an annual summer school for graduate students in the field of electrochemistry. There is also an annual electrochemistry national symposium, with rotating organisation.

There are plans for courses/workshops in the framework of the **NWA-BatteryNL** project, and an annual BatteryNL consortium meeting as well as an annual Battery Day and an annual catalysis meeting, the latter aimed at PhD students. Other initiatives are more in the type of lifelong learning, like courses for people in industry, politicians/civil servants on Batteries and Storage.

At Vrije Universiteit Brussel (VUB), the Battery Innovation Centre provides advanced research opportunities in energy storage, providing the research solutions from the material level until the system integration level, including second life and recycling. Students gain hands-on experience in cutting-edge battery technologies through applied running research projects in top notch topics such as self-healing, sensor integration or advanced Battery Management Systems (among other). Additionally VUB provides in its Master Program the course "Fuel Cell and Batteries" where a focus of battery research needs is provided along the full value chain.

Together with VUB, KU Leuven and in collaboration with Agoria, offers a specialized post-university program on Battery Systems, designed to meet the increasing demand for battery technology expertise, covering topics from basic principles to advanced applications. Hasselt University (UHasselt), as part of EnergyVille, engages in comprehensive battery research across the entire value chain, preparing students for various roles in the battery industry.

Beyond academia, Belgium offers professional training programs for those already working in the sector. TVH Academy provides a one-day Li-ion Batteries course tailored for engineers involved in maintaining and repairing electric machines with lithium-ion batteries, emphasizing safety and practical knowledge. The Battery Winter School, scheduled for March 2025, will offer immersive training experiences at leading industrial sites, supervised by experts, to equip participants with foundational skills and knowledge in battery technology.

In the **United Kingdom**, the **Faraday Institution** serves as the focal point for battery education and research. Established in 2017, it is the UK's independent institute for electrochemical energy storage research, skills development, market analysis, and early-stage commercialization. The Faraday Institution offers a range of programs aimed at developing a skilled workforce for the battery industry. For undergraduates, it has established a high-quality summer internship program, providing first-hand experience in the battery sector to over 250 participants to date. At the doctoral level, the institution offers a comprehensive PhD training program, equipping researchers with advanced skills to become future leaders in battery science and engineering. This program includes training budgets, career development plans, and opportunities for internships with industry partners. Additionally, the Faraday Institution organizes monthly Masterclasses and in-depth tech courses in collaboration with the Henry Royce Institute and other key organizations, focusing on enhancing the knowledge and skills of UK-based battery researchers. These initiatives are complemented by a strong commitment to STEM outreach, with over 70 PhD researchers trained as STEM ambassadors to inspire young people to pursue careers in battery research and related fields.

Both France and Germany are actively fostering collaborations between academia and industry to ensure that educational programs align with real-world applications and emerging technologies. This approach not only enhances the quality of education but also ensures that graduates are well-prepared to contribute effectively to the energy transition and the growing battery industry in Europe.

In summary, Western Europe's concerted efforts in enhancing battery education and training reflect a strategic commitment to leading the global energy transition. Through substantial investments, innovative educational programs, and strong academic-industry partnerships, France,

Germany, and the United Kingdom are equipping their workforce with the expertise required to drive advancements in battery technology and sustainable energy solutions.

2.4 Education and Training in Eastern Europe

In recent years, **Eastern Europe**, including the **Baltic states**, has witnessed a significant surge in educational initiatives centred around battery technology and energy storage. This momentum is largely driven by the establishment of gigafactories by Asian companies and the strategic efforts of national and regional organizations to align educational programs with the evolving energy sector.

Hungary is at the forefront of this transformation. The **Hungarian Battery Association**, primarily an industry-focused entity, has been instrumental in coordinating efforts to develop new curricula related to battery technologies. Their **National Battery Industry Strategy 2030** and accompanying action plan emphasize the expansion of education across all levels, aiming to cultivate a workforce adept in the latest battery innovations.

In **Slovenia**, academia is proactively integrating battery-related topics into higher education. The **University of Ljubljana** has introduced a lecture series on climate change and green transition technologies at its Faculty of Physics and Mathematics. Concurrently, the Faculty of Chemistry and Chemical Technology is developing a master's program slated to commence in the 2025/2026 academic year. This program will encompass studies in batteries, hydrogen technology, green chemistry, and Power-to-X, providing students with interdisciplinary knowledge essential for advancing sustainable energy solutions.

Poland boasts a robust battery research landscape across several universities, including those in Gdańsk, Kraków, Poznań, and the **Warsaw University of Technology (WUT)**. These institutions offer master's and doctoral programs focusing on various aspects of battery technology. Notably, WUT's Faculty of Chemistry is expanding its **Materials for Energy Storage and Conversion (i-MESC)** joint master's program. This initiative aims to educate specialists proficient in both the fundamentals and engineering aspects of electrochemical energy generation, storage, and conversion. The curriculum spans topics from raw material processing and functional material synthesis to cell production and recycling, equipping graduates to lead research and development projects globally.

The **Czech Republic** has established the **Czech Battery Cluster (CBC)** in 2022 to foster collaboration between the public and private sectors. CBC's mission is to support partnerships among private companies, research institutions, and public entities, focusing on projects that drive an emission-free economy and technological advancements in industry. By bridging the scientific and industrial communities, CBC enhances competitiveness and promotes technical education tailored to 21st-century market needs.

In **Slovakia**, a consortium comprising public and private organizations has been actively engaged in battery research and development since 2020. Led by the **Centre for Advanced Material Application (CEMEA)** of the Slovak Academy of Sciences, this multidisciplinary project emphasizes the training of young talents poised to excel in innovative technologies. Recognizing the automotive

industry's shift towards electrification, Slovakia is committed to cultivating specialists in battery technologies to meet the sector's evolving demands.

The **Baltic states** are also making notable strides in energy storage education and infrastructure. **Estonia**, for instance, is contributing to the European battery supply chain by exploring sustainable alternatives to critical raw materials, such as locally sourced green graphite and developed curved graphene. These initiatives aim to reduce dependence on external sources and enhance local battery ecosystems. Additionally, the **Tallinn University of Technology (TalTech)** offers over 30 fully accredited international degree programs, including those in engineering and technology, which are pivotal in advancing battery research and education in the region.

At a broader level, the **European Battery Alliance Academy**, supported by the European Institute of Innovation and Technology (EIT) and EIT InnoEnergy, plays a pivotal role in coordinating reskilling and upskilling efforts across member states. With a grant of €10 million under the REACT-EU initiative, the Academy aims to address the demand for 800,000 skilled workers in the battery industry by 2025, ensuring a well-prepared workforce to support the sector's rapid growth.

In summary, Eastern Europe and the Baltic states are actively enhancing their educational landscapes to meet the burgeoning needs of the battery and energy storage industries. Through strategic collaborations, curriculum development, and investment in research, these regions are positioning themselves as key contributors to Europe's sustainable energy future.

2.5 Summary of the educational landscape

Battery education across Europe is closely tied to regional industrial priorities, with significant differences in how countries train their workforce to meet industry needs. **Northern Europe**, particularly Sweden and Finland, has a strong research-driven approach with universities like Uppsala University, Chalmers, KTH, and Aalto working closely with **Northvolt** and other battery producers. Education focuses on advanced materials, battery recycling, and automation, aligning with the region's leadership in **sustainable gigafactories** and **circular economy initiatives**.

Western Europe, led by Germany and France, has the most structured and industry-integrated battery education ecosystem. Germany's **automotive and battery manufacturing sector**, including **Volkswagen, BASF, and BMZ**, drives the need for advanced engineering programs at RWTH Aachen and TU Braunschweig. France, through **France 2030**, is expanding training programs linked to **Verkor, ACC, and Renault's gigafactories**, ensuring a steady supply of technicians, engineers, and researchers.

Southern Europe is expanding its battery education to support emerging industrial hubs. **Spain and Portugal** are growing their manufacturing and recycling sectors, with companies like **Iberdrola and Galp** investing in production facilities. Universities in Barcelona, Porto, and Évora are adapting curricula to meet workforce demands, but vocational training remains underdeveloped compared to Northern and Western Europe. **Italy**, home to **Italtvolt and major automotive players**, has strong academic programs at Politecnico di Torino and Bologna, but still lacks extensive hands-on training.

Eastern Europe, including Poland, Hungary, and Slovakia, is experiencing a rapid industrial shift driven by **Asian battery giants like CATL, Samsung SDI, and SK Innovation**, who are building gigafactories in the region. Education is expanding to meet workforce needs, with Poland's **Warsaw University of Technology** and Hungary's National Battery Industry Strategy emphasizing training for large-scale

production. The **Czech Republic and Slovakia** are strengthening industry-academic partnerships to support their growing role in European **EV supply chains**. The **Baltic states** are still in the early phases of developing structured battery education, with a focus on sustainable materials and supply chain integration.

Overall, European battery education is evolving to align with industrial needs. Several initiatives are running and are well distributed in Europe with some more focus in the northern countries, maybe because of high fundings available and stronger industrial support.

3 SURVEYS

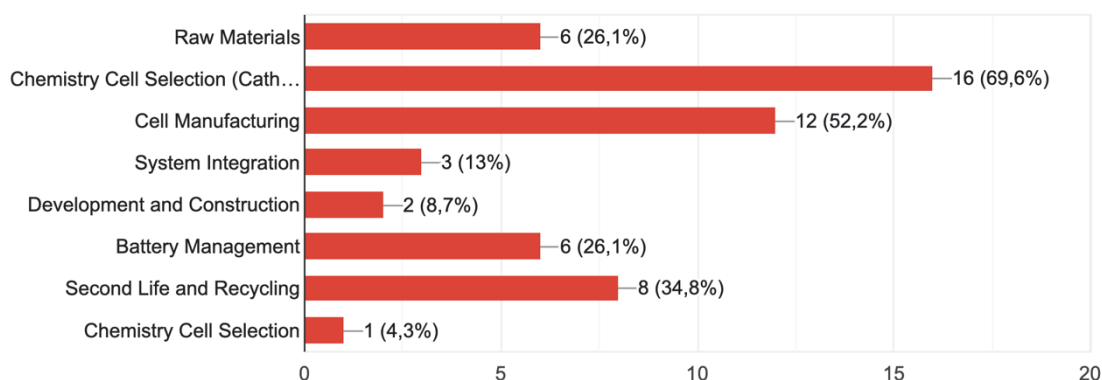
3.1 Battery 2030+ survey

Building on the updated state of the art above, the second part of this deliverable focuses on the educational needs that should be developed and implemented in Europe. To gather additional insights and foster discussions, a questionnaire was designed and distributed to Battery 2030+ members and administered to attendees of the Battery 2030+ annual meeting (see Annex 1). The survey aimed first to gain a comprehensive understanding of existing educational activities and then to identify gaps and unmet needs in the educational process. The respondents were predominantly university-affiliated members but 20 percent were industry representatives. Representatives from academia mainly represented small research groups, but given their teaching potential, they obviously have access to a wider range of doctoral students and post docs.

The respondents represented various links in the link production value chain and their structure is shown below. In this report, we only present survey results related to the current educational landscape and education needs, while parts addressing future curricula will be presented in the upcoming deliverable D4.2.

1. Which part of the value chain you representing?

23 odpowiedzi



Respondents' guidance on specific needs in battery education.

Respondents were asked about the shortcomings of the teaching structure in the link area. They pointed out the following aspects:

- Safety related to batteries and materials. Transportation of batteries, toxic materials, etc.
- Process chemistry for batteries.
- Remanufacturing as an alternative to recycling, reverse logistics strategies, Focus on LMT in mapping value chain and understanding volumes.
- Hands on experience!

- From one side, number of educational platforms is growing. Lack of information what and where can be found for students of different levels. For example, master programs, separate courses, separate lectures.
- Standards and good scientific practice
- Budget for training and trainers, workshop series, active applied trainings
- Estimation of State of Health developments
- BMS (Battery Management System) knowledge
- Industrial knowledge and perspective
- Fundamental electrochemistry
- Education on battery domains for non-technical people that are linked to projects, need to start on low grades education (teenagers to gain future researchers and gain social awareness about its importance).
- Hands on activities are few, especially with respect to battery manufacturing (for some geometries, e.g., cylindrical or prismatic)
- Fire Safety
- Regulatory, societal and economical aspects.
- Techno economical aspects
- General awareness on how to access any battery repair/replacement services especially for the car industry. Also, maybe safety issues should be in the focus of battery education projects.

These survey results highlight several critical gaps in battery education across Europe. Key needs include enhanced training on battery safety, materials handling, fire hazards, and regulatory aspects—essential topics given the increasing deployment of battery technologies. Additionally, there is a strong demand for hands-on experience, particularly in battery manufacturing and Battery Management Systems (BMS), areas where practical exposure remains limited. Process chemistry, remanufacturing, and reverse logistics also emerge as priorities, reflecting the growing focus on circular economy strategies.

Another major challenge is the fragmentation of educational resources, with a lack of clear information on available courses, programs, and training opportunities at different levels. There is also a recognized need to expand education beyond technical domains, incorporating industrial perspectives, techno-economic considerations, and outreach to non-technical audiences, including policymakers and younger students.

To address these gaps, Battery 2030+ could play a key role in advocating for structured, Europe-wide educational initiatives, building on the BEPA position paper. This could include the development of a centralized platform for educational resources, the promotion of hands-on training programs in collaboration with industry, and the establishment of targeted funding schemes for workshops, trainers, and active learning experiences. Strengthening synergies between academia and industry will

be essential to ensure that higher education aligns with the skills required for the future of battery research, manufacturing, and sustainability in Europe.

Since one of Battery 2030+'s tasks is to continuously monitor existing educational programs, respondents were asked whether any new educational initiatives had emerged in the last 3 years and whether any non-standard/innovative teaching methods had been used. The results highlight a growing number of specialized programs in electrochemical energy storage and battery technologies across Europe. Several universities have introduced new courses, including a lecture on Electrochemical Energy Conversion and Storage at the University of Würzburg, a standalone Li-ion battery course at LUT University, and a developing master's program on Li batteries at the same institution. Innovative digital learning formats are also gaining traction, such as the fully online Elmo-Lion PhD course, MOOCs like Powering a Mobile World, and a Life-Long Learning course on EV batteries. Large-scale initiatives such as the Norwegian MoZEES and Battery projects are also playing a key role in training PhDs and postdocs. Collaborative efforts, such as those between GS-EES and ALISTORE or within the i-MESC master program, further support knowledge sharing. Other noteworthy initiatives include Battery Days lab courses, mentoring programs, and graduate-level intensive courses on battery technologies.

The survey underscores a dynamic and evolving educational landscape, with increasing interdisciplinary collaboration and a strong push toward digital and hands-on learning experiences.

3.2 Surveys in Germany

In Germany, two notable surveys were conducted that focus on the training needs of graduates (MSc), PhD students, and post-docs—collectively referred to as the skilled workforce—who are newly employed in the industry, while simultaneously reflecting the skills needs identified by industry representatives.

QualiBattBW is one of the six regionally-oriented qualification alliances in Germany which unites scientific institutions, educational providers, and battery innovation clusters. Sponsored by the Association of German Engineers (VDI) and the Association for Electrical, Electronic, and Information Technologies (VDE), these alliances address qualification needs along the entire battery value chain. The goals of the alliances are twofold:

- a) Short-term goal: To enable the targeted qualification and retraining of skilled workers for the specific needs of regionally-based companies within the battery ecosystem.
- b) Long-term goal (up to 2028): To strengthen the connection between research and development, education, and industry along the entire value chain.

Within the QualiBattBW alliance, **7 qualification modules** have been identified as the most relevant within which a total of 47 topics were defined.

- Cell Performance Analytics
- Battery System Technology
- Industrialisation and Production
- Hazard Potential in Battery Recycling
- Markets and Business Models
- Digitalisation
- Safety / Safe Battery Systems

Two qualification modules were identified as absolutely and urgently relevant, namely *Industrialisation and Production* and *Markets and Business Models*.

At the **European Battery Show 2024** held in Stuttgart, CELEST organised a workshop and identified both the technical and practical skill needs based on feedback from both industry representatives as well as postdocs and PhD students. From the industry side, 21 needs were identified. The group of postdocs and PhD students, in the following denoted as “early career researchers” (ECRs) produced a list with 26 items.

We have employed **ChatGPT4o** to categorise the 94 needs from the two surveys into six broader categories. And consolidate the needs to no more than five per category. The full list of identified needs is provided in Annex 2.

A consolidated list was created in a subsequent step, again using ChatGPT4o, removing redundancies and focusing on the most impactful items:

Bridging Fundamentals and Applied Knowledge (Ensuring a strong foundation in battery science, with interdisciplinary and future-focused knowledge.)

- **Fundamentals of Electrochemistry, Chemistry, and Materials Science** → Essential for understanding battery reactions, material properties, and performance limitations.
- **Mathematical and Physical Understanding of Battery Functions** → Strong physics and quantitative skills are needed for modeling, diagnostics, and optimization.
- **Interdisciplinary Knowledge Across Chemistry, Physics, and Engineering** → Batteries require expertise from multiple disciplines for full-system understanding.
- **Emerging Battery Technologies and AI Integration** → Keeping pace with AI-driven battery optimization, solid-state, and next-gen chemistries.
- **Aging, Degradation, and Failure Mechanisms** → Critical for improving lifetime, safety, and second-life applications.

Scale-Up & Manufacturing Readiness (Developing skills to transition batteries from lab-scale to large-scale production.)

- **From Materials to Industrial-Scale Battery Production** → Covers cell design, electrode processing, and scalable assembly techniques.
- **Process Technology, Automation, and Quality Control** → Ensuring consistent, defect-free production through advanced manufacturing techniques.
- **Battery Pack Integration and BMS** → Engineering robust packs with intelligent battery management systems.
- **Recycling and Circular Economy Strategies** → Designing for recyclability and implementing sustainable material recovery.
- **Safe Handling and Work in Dry Rooms and Cleanrooms** → Preventing contamination and ensuring production safety.

Advanced Characterization & Data-Driven Approaches (Utilizing data, AI, and advanced characterization for performance optimization.)

- **Big Data Analytics, AI, and Digital Twins** → Predicting battery performance, optimizing processes, and accelerating R&D.
- **Battery Modelling and Simulation** → Essential for virtual prototyping, failure prediction, and real-time performance assessment.
- **In-Situ and Operando Characterization Methods** → Real-time tracking of battery reactions for deeper insights into degradation.
- **Thermal Management and Safety Diagnostics** → Key for preventing overheating, fire risks, and performance loss.

Standardization & Best Practices (Ensuring reproducibility, safety, and compliance with global standards.)

- **International Battery Standards and Certification** → Compliance with IEC, ISO, and automotive regulations is mandatory.
- **Reproducibility and Benchmarking in R&D** → Establishing standardized testing protocols for meaningful comparisons.
- **Environmental Protection and Sustainability Standards** → Integrating eco-friendly processes and regulatory compliance into battery production.
- **Safety Risks and Hazard Assessment** → Understanding and mitigating failure risks at the cell and system level.

System-Level Thinking & Industry Integration (Adapting to industry speed, business needs, and market-driven battery development.)

- **Understanding Industrial Needs and Decision-Making Processes** → Aligning research with industry pace, cost constraints, and application-specific requirements.
- **Networking and Market Intelligence** → Awareness of global supply chains, battery industry players, and emerging business models.
- **Battery Pack System Integration and Power Electronics** → Connecting batteries with electric drivetrains and energy storage systems.
- **Regulatory Frameworks for Recycling and Second-Life Use** → Ensuring compliance and economic viability of battery end-of-life strategies.

Soft Skills & Innovation Management (Developing career-critical competencies beyond technical expertise.)

- **Effective Communication and Leadership Skills** → Translating complex technical findings for decision-makers and cross-functional teams.
- **Project Management and Agile Thinking** → Managing research efficiently while adapting to fast-paced industry shifts.
- **Entrepreneurial and Business Acumen** → Understanding the economic impact of battery technologies and commercialization strategies.
- **Creative Thinking and Problem-Solving** → Encouraging innovative, outside-the-box solutions for battery challenges.
- **Smart Collaboration Across Disciplines and Industries** → Building strong relationships with engineers, policymakers, and investors.

3.3 Analysis of education needs

The survey highlights key gaps and opportunities in higher education for battery research and innovation in Europe. While new educational initiatives have emerged in recent years—ranging from specialized master's programs to MOOCs and vocational training—there is still a clear need for more structured, accessible, and practice-oriented education. Respondents emphasize the importance of hands-on experience, particularly in battery manufacturing, safety, and remanufacturing, alongside fundamental knowledge in electrochemistry, process chemistry, and Battery Management Systems (BMS). Additionally, regulatory, societal, and economic aspects need stronger integration into curricula to ensure a comprehensive understanding of the battery value chain.

A major challenge identified is the fragmentation of educational resources. Despite the growing number of courses and training programs, there is a lack of centralized access to information, making it difficult for students and professionals to navigate available opportunities. Addressing this issue could involve promoting knowledge-sharing platforms and enhancing collaboration between academic and industrial stakeholders. Moreover, respondents highlight the need for interdisciplinary approaches, secondments in industry, and entrepreneurial training to bridge the gap between research and commercialization.

Regarding teaching methodologies, most new courses still rely on traditional lecture-based formats, revealing a window of opportunity for more interactive and innovative approaches. Suggestions include digital tools, virtual labs, hybrid learning, industry visits, mentoring programs, and the “train-the-trainer” model. Expanding online teaching formats, disseminating open-access materials, and leveraging widely used platforms such as YouTube could further democratize access to battery education.

4 CONCLUSION

To ensure Europe remains a leader in battery innovation, Battery 2030+ must continue its efforts in monitoring educational needs and fostering structured, high-level training programs. A potential way forward could involve establishing a European education task force, strengthening ties between universities and industry, and securing dedicated funding for practical training and interdisciplinary learning. By embedding sustainability, advanced modelling, and smart functionalities into higher education, we can equip the next generation of scientists and engineers with the skills needed to drive the future of batteries in Europe.

The educational landscape for battery research and development across Europe is evolving rapidly to meet the growing demands of the industry. These deliverable highlights significant developments and emerging trends in battery education, identifying both the current strengths and critical gaps. While Northern and Western Europe have made the most progress in integrating battery technologies into higher education, with strong links between academia and industry, Southern and Eastern Europe are accelerating their efforts to catch up. Programs in Northern Europe, particularly in Sweden and Finland, emphasize interdisciplinary training, sustainability, and hands-on experience in battery manufacturing. In Western Europe, countries like Germany and France lead with robust academic curricula and industry collaborations, focusing on the entire battery value chain from raw materials to recycling.

Southern Europe is expanding its battery education landscape, with Italy, Spain, and Portugal developing programs that align with their emerging manufacturing and recycling sectors. However, there remains a need to further develop vocational training and industry-specific courses. Eastern Europe, driven by the establishment of gigafactories, is rapidly developing educational programs to support this industrial shift. Countries like Poland and Hungary are particularly focused on workforce development for large-scale battery production, while Slovenia and the Czech Republic are fostering academic-industry collaborations to drive innovation.

Key educational needs across Europe include enhanced practical training, particularly in battery manufacturing and Battery Management Systems (BMS), and the integration of sustainability and circular economy principles into curricula. The findings highlight a fragmented educational landscape with a lack of centralized information, making it difficult for students and professionals to navigate available training opportunities. Furthermore, interdisciplinary and hands-on learning approaches are underrepresented, suggesting the need for more dynamic, industry-focused educational models that bridge the gap between academic research and practical applications. Moving forward, Europe must continue to innovate and collaborate across regions to ensure a highly skilled workforce capable of supporting the rapid growth of the battery industry and the energy transition.

In the next step, these findings will be used to develop ideas for new, pan-European curricula in battery research and development (Battery2030+ Deliverable 4.2).

ANNEX 1 – BATTERY2030+ SURVEY

1. Email *
2. Surname *
3. Name *
4. Are you representing: *
 - ☐ Academia
 - ☐ Industry
5. Number of employees/students? *
6. 1. Which part of the value chain you representing? *
 - ☐ Raw Materials
 - ☐ Chemistry Cell Selection
 - ☐ Cell Manufacturing
 - ☐ System Integration
 - ☐ Development and Construction
 - ☐ Battery Management
 - Second Life and Recycling
7. 2. Are there any specific needs in your best knowledge is permanently omitted in battery education projects?
8. 3. Are there any initiatives of an educational nature known/emerged in your organization over the last 2 years. Can you add a name or short description?
9. 4. Are they of the following nature: *
 - ☐ Lecture based
 - ☐ Laboratory/Practice
10. 5. In your opinion, have they used new teaching methods/courses if yes, what kind? *
11. 6. How can we make (your) lectures educational projects broadly accessible? *
12. 7. Are you ready to make the lecture more accessible. *
 - ☐ Yes
 - ☐ No

ANNEX 2 – SURVEY RESULTS FROM GERMANY

The categorized full list of qualification needs is shown in the following, where we give the source for each item in parentheses:

Bridging Fundamentals and Applied Knowledge (*Focus on core scientific understanding and interdisciplinary integration*)

- **Electromagnetic Compatibility (EMC) (Battery Show)** → Essential for preventing interference issues in battery management systems (BMS) and electric drivetrains.
- **Solid scientific and technical foundation (Battery Show)** → Ensuring a strong grounding in electrochemistry, materials science, and engineering.
- **Equal scientific and technical foundation (ECRs)** → A need for harmonized education across Chemistry, Physics, and Engineering.
- **Profound scientific foundation (ECRs)** → Deep domain knowledge is required to develop cutting-edge solutions.
- **Integration of electrical, electrochemical, and mathematical methods, including AI (Battery Show)** → AI and computational tools are increasingly used for battery modeling, optimization, and failure prediction.
- **Knowledge of future skills and emerging technologies (ECRs)** → Staying ahead in the field requires awareness of evolving battery tech and AI integration.
- **Introduction to Battery Technology (QualiBattBW)** → Fundamental knowledge about how batteries function, their applications, and key parameters.
- **Battery chemistry and material properties (QualiBattBW)** → Understanding the properties of active materials and their impact on performance and safety.
- **Electrode design and interface challenges (QualiBattBW)** → Key for improving battery efficiency and longevity by optimizing electrode-electrolyte interfaces.
- **Understanding electrochemical basics (QualiBattBW)** → Essential for diagnosing battery performance and designing new chemistries.
- **Mathematical understanding of battery functions (ECRs)** → Quantitative skills are required to optimize battery behavior and performance.
- **Electrochemical understanding (ECRs)** → Essential for modeling and interpreting battery behavior.
- **Understanding of aging and degradation mechanisms (QualiBattBW)** → Critical for improving battery lifetime and predicting failure modes.
- **Understanding battery failure mechanisms (QualiBattBW)** → Helps in designing safer and more reliable batteries.
- **Modeling of Battery Cells (QualiBattBW)** → Computational simulations assist in predicting cell behavior and optimizing design parameters.

- **Characterization of Battery Cells + Parameterization of Models (QualiBattBW)** → Essential for improving cell design and validating theoretical models.
- **Basics of Thermal Characterization of Battery Cells (QualiBattBW)** → Important for managing heat dissipation and preventing thermal runaway.
- **Online Tests at the Cell Level (QualiBattBW)** → Real-time monitoring of battery performance to detect early failure signs.

Scale-Up & Manufacturing Readiness (*Understanding industry processes and large-scale production challenges*)

- **Understanding the role of recycling in battery production (Battery Show)** → Integrating recycling considerations early in battery design improves sustainability.
- **Hands-on experience with batteries (Battery Show)** → Practical exposure to battery assembly and testing is crucial for industry readiness.
- **Practical experience in industry (Battery Show)** → Direct experience in manufacturing and testing environments provides essential insights.
- **Process technology and scale-up (QualiBattBW)** → Transitioning from lab-scale to industrial-scale production requires specialized knowledge.
- **Quality assurance and control in battery production (QualiBattBW)** → Ensuring defect-free production and compliance with safety standards.
- **Industrial manufacturing processes (QualiBattBW)** → Covers electrode fabrication, cell assembly, and automation technologies.
- **Formation, conditioning, and diagnostics (QualiBattBW)** → Final processing steps are critical for stabilizing battery chemistry and ensuring performance.
- **From Material to Battery Cell (QualiBattBW)** → Understanding the complete production chain from raw materials to a functional cell.
- **Construction and Characterization of Battery Packs (QualiBattBW)** → Key to designing efficient and durable battery modules for automotive and stationary storage.
- **Scaling of Battery Production Technologies (QualiBattBW)** → Necessary for mass production, ensuring efficiency, quality, and cost-effectiveness.
- **Planning of Battery Cell Factories (QualiBattBW)** → Involves site selection, infrastructure planning, and supply chain management.
- **Safe Work in Cleanrooms and Dry Rooms (QualiBattBW)** → Critical for handling moisture-sensitive battery components safely.
- **Contacting Battery Cells to Modules (QualiBattBW)** → Ensuring robust electrical connections between cells in packs.

Advanced Characterization & Data-Driven Approaches (*Leveraging data and new technologies to optimize performance and predict issues*)

- **Competency in Big Data analysis (Battery Show)** → Essential for managing and interpreting large experimental datasets.

- **Experience with handling Big Data (ECRs)** → Researchers need skills in data wrangling, analytics, and machine learning.
- **Battery modeling and simulation (QualiBattBW)** → Key for predicting performance and optimizing new chemistries.
- **In situ and operando analytics (QualiBattBW)** → Enables real-time monitoring of electrochemical reactions within batteries.
- **Performance and lifetime testing (QualiBattBW)** → Necessary for evaluating battery durability under realistic operating conditions.

Standardization & Best Practices (Improving reproducibility, quality control, and benchmarking of research and production efforts)

- **Updated and expanded curricula (Battery Show)** → Reflecting the latest industry needs in education and training.
- **Knowledge of standardization and regulations (QualiBattBW)** → Understanding legal and safety requirements for batteries.
- **Safety standards and certification (QualiBattBW)** → Ensuring compliance with international safety norms.
- **Recycling processes and regulatory aspects (QualiBattBW)** → Addressing sustainability challenges and legal frameworks.
- **Environmental protection awareness (ECRs)** → Ensuring sustainability and eco-friendly approaches in battery production and recycling.

System-Level Thinking & Industry Integration (Understanding the broader ecosystem and business needs of battery technology)

- **Comprehensive understanding of industry needs (Battery Show)** → A systems-level view of battery applications, supply chains, and market trends.
- **Understanding and managing company pace (Battery Show)** → Adapting to rapid industrial development cycles.
- **Understanding the speed and decision-making processes in industry (Battery Show)** → Industry operates on tight timelines, requiring quick decision-making.
- **Networking and market knowledge (ECRs)** → Understanding battery markets, supply chains, and global competition.
- **Understanding of global networks (Big industry players and companies) (ECRs)** → Awareness of key industry stakeholders and technological trends.

Soft Skills & Innovation Management (Essential for career success beyond technical expertise)

- **Adaptability and willingness to relearn (Battery Show)** → Keeping up with rapidly evolving battery technologies.
- **Business acumen and thinking (Battery Show)** → Understanding cost structures, return on investment, and commercialization strategies.
- **Entrepreneurial thinking and action (ECRs)** → Recognizing opportunities for innovation and business development.

- **Effective communication at various management levels (Battery Show)** → Bridging the gap between technical experts and executives.
- **Networking skills with non-academics (Battery Show)** → Engaging with policymakers, investors, and supply chain partners.
- **Teamwork and collaboration skills (ECRs)** → Essential for multidisciplinary and global projects.
- **Creative thinking and "Out-of-the-Box" problem solving (ECRs)** → Helps in tackling complex R&D challenges.
- **Pragmatism and practical approach (ECRs)** → A mindset needed to transition from theory to application.
- **Ability to present insights clearly and understandably (ECRs)** → Crucial for influencing decisions and securing funding.
- **Smart interaction with leaders (ECRs)** → Building credibility and effective stakeholder engagement.
- **Challenging traditional habits (ECRs)** → Encouraging disruptive innovation and new approaches.