Batteries Europe

Position paper

Education & Skills Task Force

April 2024

In cooperation with

BEPA Batteries European Partnership Association

BATTERIES EUROPE SECRETARIAT

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Work Package 4 – Strengthening a holistic battery R&I ecosystem with synergistic efforts

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Written by	Spyridon Pantelis (EERA), Jacqui Wigg (EITInnoEnergy), Roberto Pacios (CICe), Ganna Gladkykh (EERA), Eliana Quartarone (UNIPV), Edel Sheridan (SINTEF), Marlene Eisenträger (VDI/VDE-IT), Christoph Grzeschik (VDI/VDE-IT), Dimitra Maleka (EITInnoEnergy).	2024-04-26
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EXECUTIVE SUMMARY

There is a critical imperative to address the clean energy transition from a **holistic and cross-sectorial perspective** with the goal to advancing clean energy research[1]. Such emphasis is evident in the priorities outlined in the SET Plan, underscoring the significance of addressing cross-cutting issues to expedite the development and deployment of clean and efficient energy technologies[2,3]. Within Priority 4, non-technological factors such as skills and sustainability are recognised as **pivotal facilitators for driving progress in battery technologies**, thereby bolstering EU competitiveness in the global battery sector.

Cross-cutting topics form the cornerstone of activities within the Batteries Europe ecosystem. In the past years **six cross-cutting Task Forces** have been actively engaged in facilitating collaboration among research and industry experts. Unlike the established Working Groups which is the core collaboration framework within Batteries Europe and mirror the distinct stages of the battery value chain (from raw materials to applications), the Task Forces focus on topics that extend beyond purely technological considerations. They prioritise pivotal cross-cutting topics crucial for the development of battery technology, which are integral to multiple aspects of the value chain. These topics encompass **Education & Skills, Digitalisation, Sustainability, Safety, Hybridisation, and Social Sciences & Humanities**, underscoring the comprehensive approach needed to advance battery technology effectively.

The Task Forces are operated in collaboration with the Batteries European Partnership Association (BEPA) and they are accessible and open for participants to join freely. As of April 2024, they have facilitated the **cooperation of over 350 experts**, fostering an inclusive environment for collaboration and knowledge exchange within the Batteries Europe ecosystem. With the aim of enhancing the integrated R&I ecosystem across these cross-cutting domains, the collaboration has led to the drafting of **six position papers**. These papers, included in the current publication, seek to highlight the R&I cross-cutting needs of the battery technology, offering **strategic guidance to policymakers at both European and national levels**. Additionally, they hold significant value not only for researchers and large enterprises but also for SMEs. These papers serve as valuable resources to inform, share knowledge, and foster new opportunities for collaboration across the battery industry, facilitating informed decision-making and driving innovation at various levels of engagement.

The current publication provides an updated version of the four existing position papers initially published in 2020 by the Task Forces focusing on Education & Skills, Digitalisation, Sustainability, and Safety. Additionally, it introduces two "new" Task Forces dedicated to Hybridisation and Social Sciences and Humanities. These newly established Task Forces illuminate relatively new and less explored avenues, laying the groundwork for accelerated and more comprehensive development in these vital domains within the battery industry.

[1] EERA White Paper on the Clean Energy Transition: https://mailchi.mp/eera-set/clean-energytransition
[2] COM(2023) 634 final of 20.10.2023 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023DC0634
[3] European Commission, Directorate-General for Research and Innovation, SET plan interim evaluation final report, Publications Office of the European Union, 2022 https://data.europa.eu/doi/10.2777/939719

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Batteries Europe Task Force Education & Skills

Chair:	Silvia Bodoardo (POLITO)
Co-Chair(s):	Robert Dominiko (Slovenia Institute of Chemistry) & Axel Thielmann (Fraunhofer)
Technical coordinator:	Jacqui Wigg (EIT InnoEnergy Skills Institute)
Lead authors:	Anders Norberg (Skellefteå municipality) Antonio Martins (University of Porto) Axel Thielmann (Fraunhofer) Daniela Chrenko (UBFC) Henning Lorrmann (Technical University of Applied Sciences Würzburg-Schweinfurt) Ismam Bin Hasnat (EIT InnoEnergy Skills Institute) Silvia Bodoardo (POLITO) Victor Trapp (Fraunhofer ISC) Willy Tomboy (Detomserve Gcv) Wouter Ijzermans (BEPA)
Contributing Authors:	Dimitra Maleka (EIT InnoEnergy Skills Institute) Jakub Stolda (ASA) Axel Thielmann (Fraunhofer ISI) Montse Galceran (CIC energiGUNE) Teresa Mata (INEGI)
Task Force Members:	Albertó Gómez Núñez, Anwar Ahniyaz (RISE), Arian Mahzouni (Regenerative Technologies Research Group, Department of Informatics, University of Oslo), Anita Narbro (Turku University of Applied Sciences), Anna Vanderbruggen (Helmholtz Institute Freiberg for resources technologies), Avireddy Hemesh (Leitat Technological Center), Bernhard Fäßler (UIA), Dinesh Thirunavukkarasu (Institute for Automative Engineering), Ekaitz Zulueta (University of the Basque Country), Erwin Marckx (EUROBAT), Francesco Braghin (Polimi), Francesca Amici (Polito), Gerardo Petruzziello (University of Bologna), Guillaume Thenaisie (VITO), Hans-Georg Schweiger (Technische Hochschule Ingolstadt), Ilaria Pucher (Green Energy Storage), Julia Amici (Polito), Kaan Cakti (Istanbul Teknik Insaat), Kristina Edström (Battery 2030+ at Uppsala University), Linda Arnold Triangeli (VDI/VDE-IT), Marcello Colledani (Politecnico di Milano), Mari Lundstrom (Aalto University), Marek Spanyik (ASA), Matthias Vetter (Fraunhofer), Metehan Ciftci (University College London), Mihaela Buga (National Research and Development Institute for Cryogenics and Isotopic Technologies), Nathalie Saulnier (University of Picardie Jules Verne), Nicolas Drachenfels (LiPLANET e.V.), Philippe JACQUES (EMIRI), Robert Dominko (Slovenia Institute of Chemistry), Stefano Arciprete (EIT Raw Materials), Subhasis Ray (XIM University), Tina Schnepper (Fraunhofer), Ulla Lassi (University of Oulu), Xavier Montagne (Research Franch Government)

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Definition
ALBATTS	The Alliance for Batteries Technology, Training and Skills
BEEC	Batteries Europe Education Commission
BEPA	Battery European Partnership Association
CVET	Continuing Vocational Education
EHEA	European Higher Education Area
ESS	Energy Storage System
GWh	Gigawatt hour
IVET	Initial Vocational Education
ICE	Internal Combustion Engines
LIB	Lithium-Ion Batteries
MESC	Materials for Energy Storage and Conversion
MOOC	Massive Open Online Course
SME	Small and medium-size enterprises
SSbD	Safe and Sustainable by Design
STEM	Science, Technology, Engineering and Mathematics
TTT	Train the Trainers
xEV	Electric Vehicle

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1 INTRODUCTION AND MOTIVATION

Addressing global challenges of climate change and human and environmental health urges continuous research, development, and innovation. At the same time, it also fuels the urgency to develop a highly skilled workforce, adapted to emerging technologies, whilst also driving the industrial sectors towards adapting to future socioeconomic realities. This should help avoid talent shortages by 2030 and beyond.

The European Commission highlights investment in education, science, technology, research, innovation, and digitalisation as a prerequisite for achieving a sustainable EU economy that meets the Sustainable Development Goals of the United Nations[1]. Additionally, Horizon Europe (HE) reflects on education and training for high value skills, productivity, and growth as well as fostering the EU digital transformation.

The global battery demand, driven by electric mobility (xEVs), stationary storage (ESS), and other applications, will dramatically expand the need for battery cells from 250-300 GWh in 2020 to at least 2.5-3 TWh towards 2030 and more than 10 TWh beyond[2]. The European Commission launched the European Battery Alliance[3] in October 2017 to address this industrial challenge. In Europe[1][4], the demand will increase from currently 30 - 50 GWh to 150 - 300 GWh in 2025, and at least 400 - 1000 GWh around 2030. That will be covered by the setting up of battery production capacities in Europe both by overseas companies but also, increasingly, by European cell manufacturers. Developing battery storage and mobility is one of the key pillars of the European Green Deal with strong incentives for the creation of a European Battery Value Chain. The main open question is how successful EU headquartered manufacturers will be and how production will be distributed between European and other world regions.

A **skilled workforce** along the entire Battery Value Chain will therefore be decisive for European companies and industries to be competitive and sustainable[5]. It is estimated that the job market impact of the establishment of a GWh battery production facility and the full battery ecosystem around is on the level of several hundred people directly and much higher when including also indirect employment effects. Considering the total Battery Value Chain from raw materials, components, cells to battery integration (e.g. in xEVs) and recycling as well as equipment manufacturing the direct and indirect employment effects in Europe are estimated to be 800.000 around 2025, 1.5 Mio by 2030[2] [2,6]. While there is a leverage effect of about 10 (i.e. with 1 battery expert needed in total about 10 direct and indirect jobs along the entire Battery Value Chain are connected) this means that, several hundreds of thousands of people with knowledge and skills on different aspects related to batteries

[1] *Europe*: a wide definition for European countries, both EU member countries and candidate countries. Switzerland, Iceland and Norway are also included.

[2] Around 2030 up to 300,000 direct jobs in Europe could be connected only with battery (materials, cells to pack, EV) manufacturing. Beyond 2030, these numbers could at least triple. Taking into account also the downstream value chain including battery-based products and a future circular battery economy the direct and indirect job might be on a level of up to several million in the long-term future.

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will be needed in the next 5-10 years and beyond at the European level and accordingly a much larger number of employees will need to be re- and up-skilled[2].

Hence, it is urgent to understand the demand for workforce and required qualifications arising across Europe: along the value chain, across the Member States, in companies, by number, as well as by qualification profiles. Core technical knowledge/skills, wider technical knowledge, and transferrable skills are of high importance. The development and expansion of different educational segments must be rapidly invested in and implemented, including Academic, Professional, Vocational and Public/User segments along with measures that stimulate gender balance in all areas.

Key points to highlight the importance of innovative education in battery field:

Addressing Rapid Technological Advancements: battery technology is evolving at a rapid pace with advancements in materials, design, and energy storage capabilities. It is essential to consider the latest developments and technologies to update the programmes and subjects/topics taught in all years.

Interdisciplinary Approach: it is essential to bridge the gap between various scientific and engineering disciplines as battery technology involves chemistry, physics, materials science, and mechanical and electrical engineering.

Research and Development Opportunities: high level education provides students opportunities to engage in research and development projects related to battery technology, to encouraging experts to look for, new relevant innovations.

Sustainability: discussions on sustainability, recycling, environmental impacts, responsible research and development practices, are part of the new curricula, addressing global challenges, such as transitioning to clean energy.

Laboratory Work and Experiments: practical, hands-on experience is fundamental in battery technology. It is crucial to conduct hands-on experiments and gain practical insights into new battery technology starting from cell production. These aspects should involve all levels from vocational training to PhD students.

Collaboration with Industry: collaboration between educational institutions and industry partners is facilitated through innovative training relevant to industry needs.

Promoting Entrepreneurship: innovative education can foster an entrepreneurial spirit, encouraging students to explore start-ups and innovative business models.

Influence on Policy and Regulation: work in education in this field should inform the development of policies and regulations related to battery technology.

1.1 Scope of the document

This Position Paper is a high-level document illustrating the joint view of the cross-cutting Task Forces, operated jointly by Batteries Europe and BEPA, on the topic of Education and Skills. The identification of the topics analysed and addressed was performed with input from relevant EU stakeholders. The main purpose of this Position Paper is to identify the current skill gaps and educational needs for

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different educational segments and across the Battery Value Chain (Figure 1) while considering the capacities for education and existing programs and measures on respective aspects. The educational segments considered are Academic, Professional, Vocational, and Public/User. Proper measures should be done to stimulate gender balance in all areas of education.

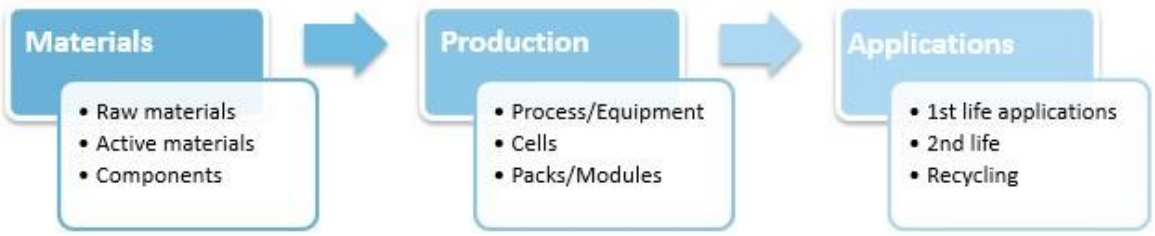

Figure 1: Battery Value Chain (simplified) as considered for the analysis in this position paper

Besides scanning the literature and projects running on this topic, inputs were received by the Working Groups in the form of an open consultation. Lastly, based on the analysis and projections, recommendations are made for the next 5 - 10 years and beyond. This Position Paper focuses primarily on Lithium-Ion Batteries (LIB) as LIB will be the dominating battery technology in the next decade, but we also anticipate a strong rise of Sodium-Ion Batteries as similar skills can be assumed. Further, skills related to other battery technology (e.g. lead acid, redox-flow batteries or any other type of batteries) are not excluded, whenever similar types of skills are required. Innovative education is a driving force behind advancements in battery technology, as it equips students with knowledge and skills, and it is required to push the boundaries of what is possible in this critical field. It ensures that future workers, at all levels, are well-prepared to make significant contributions to materials production, manufacturing, recycling and improvement of workforces in the entire value chain in a rapidly changing world, so helping Europe to compete with the great world powers in this sector.

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2 STATE OF THE ART 2020 – 2030

This brief on the State of Art of Education and Training for the European Battery Value-Chain focuses on the period 2020-2023. The position paper from Batteries Europe in 2020[7], stated that a competitive and innovative battery sector requires a properly educated and trained workforce, and that knowledge and skills gaps were challenging, and the establishing of an education and training infrastructure was in its early stages. This updated review focuses on developments in the area including issues such as the impact of the Covid-19 pandemic, volatile energy prices, political shifts and changes in national and EU battery funding. This section also highlights the ongoing work on skills identification and progress and areas that continue to need development in national education and learning infrastructures aimed at addressing the needs of battery education.

2.1 New factors

Since 2020, some new and unforeseen factors have affected the development of education and training offerings in the field of battery technology. These include:

The Covid-19 pandemic (2020-2022) developed a readiness for more flexible (e.g. including virtual) education but also temporarily slowed down development of needed new education and training programmes.

Volatile energy prices and a problematic raw materials market halted the rollout of planned battery gigafactories. This, in turn, slowed down the start of regional vocational education for these plants.

The US Biden administration's Inflation Reduction Act (IRA) caused the re-direction of some European battery value-chain investments to the American continent. Education and training development in European regions where investment is cancelled are thereby highly affected.

Recent real and potential future cuts in national and EU battery funding[8],[9] in addition may cause uncertainties and slow down or stop educational and training developments in the most critical stage of the transition to a battery economy.

2.2 Skill Card work

The consciousness about recruitment needs in the battery industry, new occupations, new skills and skills in high demand has developed considerably since 2020. Recruiting gigafactories have since defined better what they need and also gained some initial experience. The ERASMUS+ ALBATTS project[10] and EIT InnoEnergy Skills Institute have shared empirical findings and analyses and presented dozens of new occupations and skills, which are also being discussed with ESCO (The European database of Competences, Occupations and Skills), with the intent of inclusion in their database. This work benefits the education sector, HR (Human Resources) professionals and national education projects.

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2.3 National education development / learning infrastructures

National member countries' development of both the Battery Value Chain and education structures has developed considerably. National or regional education development projects and initiatives are proceeding in a number of states, such as Norway[11], France[12,13] and Germany[14,15]. Research investments are sometimes combined with training and competence centres, sometimes integrated or including pilot manufacturing lines[16].

2.4 National education development / learning infrastructures

From 2020 onwards, some re-evaluations are ongoing:

White vs Blue-collar staff: In 2020, the main focus was on education needed for specialised and general engineers and managers for the battery industry, which is pivotal for starting new production. Then as more gigafactories were starting up, a considerable need of qualified vocational workers emerged which, for example, constitutes about 80-90% of the battery cell production workforce at Northvolt Ett in Skellefteå, Sweden.

Upskilling/reskilling vs basic initial education: The initial emphasis on upskilling and reskilling of professionals with existing and relevant competence and experience is still strong, but it is becoming increasingly clear that there must be considerable recruitment of young people, coming directly from customised initial education. The development of the basic education structure for initial education, both vocational and academic, is lagging in European regions due to planning routines and long lead times for young people to go through a long education programme.

Diversity in the workforce: In European-owned industrial battery projects there is a strong emphasis on recruiting women for all tasks on all levels. This has shown to be possible. Northvolt, for example, now has about 29% women employed, aiming at a 50/50 distribution[17]. It is furthermore clear that recruitment to European battery gigafactories is done over the whole of Europe and also internationally with an immigrant workforce moving to Europe. Recruitment is presently focused on finding the right expertise with relevant experience and finding trainable people in a shorter time perspective.

Focus on battery cells or industrial methods: The first reaction of education providers to the needs of the Battery Value Chain has often been to concentrate on the batteries themselves. However, when industries are consulted, the blue-collar workforce needs mostly education and training in modern industrial ways of working, aimed at Industry 4.0 (smart manufacturing and the creation of intelligent factories)[18]; digitalisation, problem solving, cross-disciplinary and soft skills, etc. It is the workforce recruited for their existing skills in other industries, often engineers and technicians, which are prioritised for a deeper knowledge of batteries, as a new application area for their existing skills.

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2.5 Development in educational segments

2.5.1 Academic undergraduate level (EQF6)

We have not yet seen clear examples of undergraduate (bachelor level) education programmes aimed at the battery industry in particular. However, many existing undergraduate academic engineering profiles, such as electrochemistry, material engineering, machine and electrical engineering etc, constitute a good foundation for work in the battery industry. At some universities, there are courses at the undergraduate level available for interested students, but these kinds of courses are still not often optional elective courses within relevant standard programmes. An example of such a course is "Batteries for Electromobility" at Uppsala University, a flexible ordinary university course at bachelor's level.

2.5.2 Master's level (EQF7)

Master's level education is the strongest education area developed directly for the battery sector. Some examples are the following European Masters programs of which all but MESC are new since 2020:

- MESC – Erasmus Master program, *a* 2-year energy storage programme at five universities: *Amiens, Toulouse, Warsaw, Bilbao, and Ljubljana*
- Uppsala University, *Sweden*
- Chalmers University, Sweden
- University of Bayreuth, Germany
- Politecnico di Torino, Italy
- Berlin University of Applied Science, Germany

2.5.3 PhD education level (EQF 8)

EU mechanisms, as well as private and national public funding (including IPCEI on Batteries & EuBatin), offer possibilities for partners' doctoral programmes, which have increased considerably. The EU mechanisms include the ninth Framework programme (Horizon Europe), Marie-Sklodowska-Curie Networks European Training Networks (ETN) like Polystorage, Marie Skłodowska-Curie Actions (MSCA) COFUND projects like Destiny, other H2020 projects, Alistore-ERI co-shared Ph.D. program, etc.) which can provide highly skilled future development engineers, managers, researchers, and professors, but still in limited numbers. All doctoral programs allow high mobility and secondments at different universities, industrial partners, and knowledge institutions. These enable students to obtain broader knowledge and additional working experience, due to hands-on practical work in different laboratories.

2.5.4 Vocational Education: IVET & CVET (EQF 3-5)

Vocational Education and Training is a crucial area for development. IVET (Initial Vocational Education) in EU member and associated countries does not yet have the national suitable and relevant course plans for public education available, but where there are industrial needs, solutions are developed, like

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education for Northvolt's gigafactory in Skellefteå, Sweden. CVET, Continuing Vocational Education, is upskilling and reskilling the workforce with existing knowledge and skills, for both established jobs and new jobs in the sector. CVET has many providers, private and public. InnoEnergy Skills Institute (formerly EBA Academy) offers courses in most countries, tasked by the European Commission. Both IVET and CVET can be started with short lead times, but actual jobs to apply for must be locally available after the education and training to motivate individuals to participate.

2.5.5 Upskilling/reskilling

An area of upskilling and reskilling that individuals with existing relevant competences and experience often need is battery- and energy-storage-specifics. This training can allow them to apply their existing skills to a new area. They also often need new skills, and further training on existing skills. Those individuals often make use of VET offers (e.g. private virtual and physical trainings as mentioned above). This is now proceeding well, with the help of national and regional education providers, both public and private, and with transnational initiatives such as:

1) InnoEnergy Skills Institute (EBA Academy), being represented directly and with partners in most European countries, offering a wide range of up- and reskilling options.

2) The Pact-for-Skills initiative which is primarily represented by the Automotive Skills Alliance, ASA. Pact for Skills works with sectoral alliances of industry, the educational sector, the social sector, EC regions to establish up-and reskilling solutions and fund them.

3) Battery MBA - which is a leadership training programme in the sector.

However, with the absence of tailored educational trainings (by topic, size, format) the industry had to develop in-house trainings in the past years. For larger companies in this posed less problems as for SME with less resources to develop own solutions. Thus, the broader availability of up-/reskilling measures and trainings as well as the broader roll-out and through-put needs to be addressed in the coming years.

2.5.6 Autonomous learning

There are always individuals who learn on their own out of general curiosity or interest and for their own upskilling/reskilling in preparation for new job possibilities. The possibilities to do this have increased, but it is also important to get recognition and certification of the learning, especially if it is in preparation for a new job. Development work in the sector of micro-learning with badges or other recognition is ongoing, and, for example, integrated in the ALBATTS courses hosted by the ASA free course offerings. There are also many MOOC courses on battery technology on different platforms available both for free and with a paid certificate, for example, "Batteries: Powering a Mobile World" on the learning platform "Learning for Professionals". In addition, there are some relevant "micro-master" / "nanodegree" / "specialisation" course packages available in many upskilling / reskilling

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subjects, but a specialisation MOOC course package on batteries and energy storage, or on battery cell manufacturing, is still lacking.

2.5.7 Increasing volume and scale of educational offerings

As shown above, there are good examples of education development programmes and projects, and education and training possibilities in different European and associated countries. However, examples are not sufficient, educational training and programs need to ramp-up by number of offers and by through-put of people. European universities have a strong link between research and education: they can offer only what they also research. This is concerning, since relatively few European universities have sufficient battery research to also offer qualified education. Universities in regions where battery-industrial activities are ongoing or planned do also need to establish needed education in their regions, and they need to do it now. European universities do seldom sub-contract one another for delivering needed courses, but this could be an option, well in line with policies of the EHEA. We have an urgent climate-crisis which motivates new and bold solutions.

2.6 Conclusion

Engagement in developing education and training solutions and infrastructure has visibly increased on both the European and national levels. Since 2020 many good benchmarking examples have appeared but are not yet up to the projected needed volumes. Especially the academic sector's undergraduate program level is lagging behind, probably due to lack of local battery research at universities, and thereby no traditional way to train teachers. This can be addressed through collaboration between universities. The education and training for new green skills must proceed faster, and non-traditional steps are required.

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3 FUTURE SKILL NEEDS TOWARDS 2030

The battery industry needs differ **along the Battery Value Circle**. With increasing battery use, other stakeholders and the public need to be educated. A cross-disciplinary approach is recommended to create many highly educated and qualified academics, technicians, engineers, managers, consultants, entrepreneurs, and policy makers. This will call for increasing capacities within existing education platforms and the creation of new specialised courses and programs, which will assist in filling existing vacancies in the value circle and in other related areas. Education should cover seven main elements (Figure 2): Science & Technology; Integration & Applications; Circular Economy; Processing & Manufacturing; Logistics & Safety; Digitalization, and Social Impact.

Additionally, various cross-cutting soft skills should be a complementary part of the training programs.

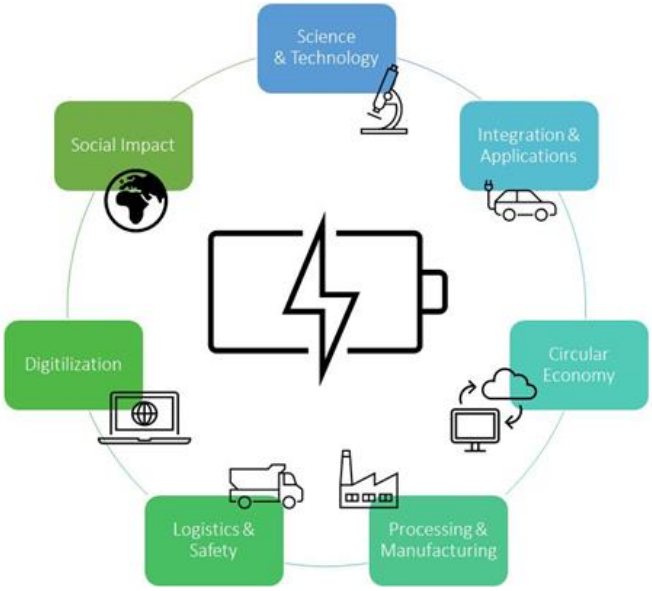

Figure 2: Main elements of battery-related education

Education and knowledge in battery components and production require accelerated efforts. A scaled battery production and ecosystem also needs a scaled workforce. A particular challenge is to increase the workforce and collective knowledge on large-scale battery production. This can be achieved by **professional education** incorporating the above main elements, and by **vocational training** for the specific work within the Battery Value Circle.

Re-skilling of the workforce from current ICE value chains but also from other matching process industries is currently regarded as a necessity for most of the qualification profiles required to enable large-scale manufacturing for cell production. In this context, **design-to-cost** and **design-to-manufacturing** aspects are of key importance. Moreover, continuous re-skilling demands for upgrading and/or renovation of production lines for future battery types and other needs must be addressed. Close synergies between companies and academia are seen as essential to achieving this continuous education.

The **product integration** on system-level requires significant skills development (e.g. engineers with more applied skills in construction and design at Bachelor and Master levels). For example, in the

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automotive industry, it is challenging to reskill employees with a mechanical background to electrical applications or to find sufficient personnel e.g. with professional education in the field.

Knowledge and skills in the actual **use phase** of the batteries, their functioning principle, and for second life of batteries will become increasingly important in the future. Operating used batteries and re-installing them for a second-use application requires a workforce with proper knowledge about ageing processes in connection with **safety**. Safety is thus a priority issue for all stakeholders throughout the entire battery lifetime and utilization. Knowledge of **battery recycling** (e.g. proper disposal, recycling options, etc.) and cross-cutting topics such as **environmental aspects, digitalisation, business models**, and **circular economy**, are increasingly important across the value circle.

Consequently, concrete actions are required in **academic education** to build up a trained workforce for the future battery industry with expertise along the Battery Value Chain in the next years. Academia should provide attractive specialised academic education programs for young students. Programs should build curricula based on interdisciplinary educational areas, with some key areas listed below for students of different disciplines:

Science & Technology: Materials science and engineering/ Electrochemistry and characterisation/ New and emerging battery materials & technologies/ Cell manufacturing /Battery testing.

Integration & Applications: Module and pack assembly including Battery Management Systems (BMS)/ Battery control and system integration/ Battery applications.

Processing & Manufacturing: Process engineering / Engineering and cell design/ Design of equipment and battery manufacturing/ quality control & testing.

Circular Economy: Re-use and Recycling/ Raw materials extraction and processing/ Design for Recycling.

Logistics & Safety: Handling and transport of batteries/ safety standards and tests/ insurance.

Digitalization: Data handling, processing and management/ artificial intelligence/ robot co-working.

Social Impact: Social sciences and Economics (related to battery manufacturing and use).

Different funding schemes and measures (e.g. EU wide pilot lines [19,20] Just Transition Fund (JTF) sources[21], Recovery and Resilience Facility funds[22], the Forschungsfabrik Batteriezellen FFB in Germany [23], the CoLabs in Portugal etc.[24]) are only a few possible initiatives which should support educational training and courses with providing access to their infrastructure (e.g. demonstrators). Graduates should have a possibility to gain practical experience and skills, for example, on battery manufacturing. It is important to develop specific courses and master programmes' curricula on specific subjects relevant to battery industries since many trained personnel (e.g. operators, technicians, process engineers, maintenance engineers with respect to the battery/cell manufacturing industry as well as electrical drive technology) will be required around production sites (who are trained either to a Master's or Doctoral level). In addition, a close connection with companies and application-oriented R&D is necessary to enable early practical work experience, and the promotion of specific internships in companies to ensure a balance between theoretical and practical knowledge. In this respect, Battery2030+ coordination and support action (CSA) includes a Work Package dedicated to developing European curricula in future battery technologies (WP4 of Battery2030+ is participated by POLITO,

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Uppsala University, CEA, CNRS, CIDETEC, CIC Energigune, KIT, NIC, DTU, VUB, MEET, WUT, AIT, TU DELFT, Aalto, NTU, and SINTEF).

Professional education is essential to have highly qualified professionals in battery production, system integration of battery-based products, and monitoring, collecting, and recycling. Educational measures should be developed and implemented jointly by training providers focused on training in the workforce collaborating with industrial partners, to reduce time, effort, and financial resources for industries on training new employees. Facilities for practical hands-on training should be established and existing facilities such as pilot lines and FFB should be used. There is a strong urgency to organise practical training sessions for trainers on pilot lines designed for educational purposes and realise specific centres spread in different geographic sites in Europe for this scope. These centres can provide education for academies, where the availability of pilot lines is reduced, but also for companies on demand, to skill and reskill their workers. This can speed up the process to educate a larger number of workers and researchers.

Two important cross-cutting needs appearing along the value chain from the raw materials to production, applications, and recycling are digital skills and a digital mindset, as well as holistic battery system understanding. All main elements (Figure 2) should be considered for professional education. With respect to large and complex projects and large-scale production facilities, there is a special need for highly experienced battery experts in upper management. They should be able to understand the technical aspects and at the same time make decisions on strategies, investment, etc.

Vocational training is critical for specific areas of the Battery Value Chain, especially with regards to increasing manufacturing capacities, where 80-90% of production employees are blue-collar workers. Special attention should be given to education on handling and transport of batteries, their installation, and testing with emphasis on safety. Such training can be offered to people with solid industrial understanding and interest in batteries, battery technology and production.

Acceleration in technology transfer is needed for all educational segments and all battery-related topics including the education of the **wider public** and of various stakeholders such as **policymakers**. For example, acceptance from the public/user is an important contribution to the opening of markets and removing barriers to the uptake of batteries/EVs. As today's awareness of the advantages of using batteries is low and concerns about safety issues are high, the wider public should be properly educated about all aspects of battery technologies, their maintenance and proper use. The predominant focus should be on generations of kids and young adults.

To achieve the above large-scale accelerated training programs, there is also a **gap in available trainers and education personnel**. Thus, besides specific **train-the-trainers programmes**, innovative approaches to this challenge need to be taken. As an example, cascade education is recommended where young students themselves educate kids in school.

To summarize the key future needs:

- The accelerated roll-out of training (reaching a large number of trainees, e.g. via virtual formats accompanied by physical hands-on training; incl. training the trainers); the period from now until 2030 is critical as we are in a strong take-off in the S-curve.

- Increased focus on vocational training and re-skilling of workforce thus also gaining experience in process scaling to achieve cross-industry transfer from other sectors to the battery sector.

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- Address circularity, critical raw materials, SSbD principles in the curricula to support Green Deal policies.

- Further educational outreach to public/end-users, elementary schools and other stakeholders is required to implement battery knowledge and thus acceptance amongst wider public and specific stakeholder groups and to sow seeds for next generation scientists and workers.

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4 GAPS AND CHALLENGES

To respond to the worldwide increase in utilisation of batteries and battery-based applications, there is to-date already a critical need for schooling at all educational levels and to train a skilled workforce, and to do this throughout the value chain. A recent report from the IEA shows that there is a significant need for workers in the battery sector at various levels[25] There are clearly identifiable gaps between the actual situation and an ideal and even an acceptable education and training level, and this is in several areas as is reflected in the diagram below:

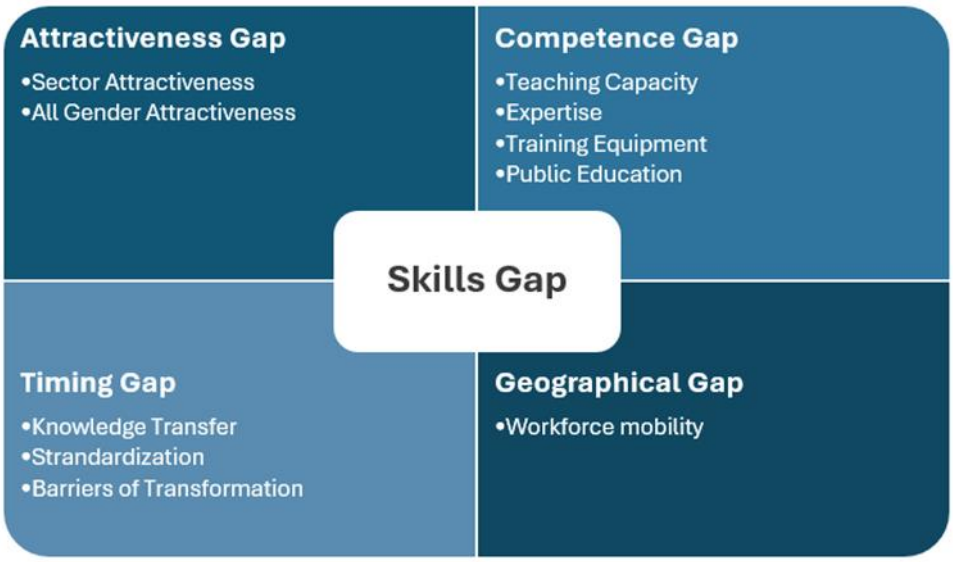

Figure 3: Four major areas concerning Skills Gaps[26]

In the remainder of this chapter, we focus on several elements from the model in the image, including the following. Most of the other themes included in the diagram are covered elsewhere in the paper.

- Expertise
- Workforce Mobility
- Standardization
- Barriers of Transformation
- Training Equipment

These gaps - very much linked to each other - create several challenges, which can be overcome with adequate countermeasures.

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4.1 Expertise

Competences in large-scale cell manufacturing are currently limited despite the new investments in battery cell manufacturing in the EU[27,28].

While the expertise of the various areas of the batteries value chain is available and well developed, it is dispersed through different graduate schools, universities and research organisations. The level of educational development differs between Member States, but they all suffer from limited teaching capacity.

To address this, The European Commission could allow for Calls for proposals to improve on required competences. Existing programs from universities, institutions and research centres can be used as stepping stones to ensure successful new training programs and learning paths for each function.

There is an opportunity to train workers over the age of 40, to acquire skills needed to start a new career in the battery sector. This will help to reduce long-term unemployment. Specific courses aimed at these people should consider that they already have work experience[29].

Also crucial to the success and/or training or a future workforce in the battery sector encompassing the whole Battery Value Chain is the need to develop strong capacity in training and teaching with adequate technical, scientific and pedagogic competences. Some of the gaps and challenges that need to be addressed in this area are[30]:

- Developing specific training and support materials to train the trainers, considering the target audience and level of expertise.
- Guaranteeing that the trainers acquire the required competences needed to efficiently transfer and evaluate acquisition of knowledge.
- Ensuring that the trainer's expertise and competences are renewed regularly in line with the evolution of scientific and technical knowledge in the battery sector, and the changes required specific to their geographic areas.
- Identify scientific and technical areas in which trainers are needed with the input of all relevant stakeholders, especially industry.
- Focus on boosting the attractiveness of the battery sector for future trainers.

4.2 Workforce mobility

Existing programs attract students from other parts of the world and therefore it is important to make it attractive for European students too. The EU could subsidise graduate schools & universities to allow for permanent and targeted communication[31].

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In addition, to ensure that mobility is no longer a limiting factor, students in each Member State ought to be able to follow studies in batteries' faculties in the different areas of battery expertise, from development of batteries to final disposal at end-of-life[32].

In order to better understand what types of communication, we can monitor specific indicators. Examples of these indicators include the actual types of educational programs, the number of students enrolled for each programme, per annum and the distribution of these students across Member States. This approach will allow for more targeted and effective communication.

Interdisciplinarity/multidisciplinary research and value chain-based training could increase the skilled workforce and remove barriers between different specialists to favour exchange of knowledge and competence between the various actors involved in the education/training sector.

4.3 Standardisation

The level of education is quite different between graduate schools, universities, research centres and even between EU Member States. Standardisation requirements in battery education are needed. The purpose should be to ensure compatibility amongst battery faculty education between educational institutions and Member States.

A barrier to overcome are the existing differences in approach between industry, academia, and training schools/centres. They have different goals and targets, due to competing interests with respect to knowledge transfer, intellectual property issues, confidentiality, and sensitive information. As a result, the specialised knowledge & expertise tend to remain internal to the company/industry. This can further complicate the development of joint educational measures between academia, training centres and industry.

Standardised and specific curricula at bachelor's and master's level for different areas of the value chain could be a valuable solution, to support early-career researchers, whilst basic STEM skills are still of significant importance. STEM skills are still essential for early-career researchers, as they are important to equip them with the critical thinking, problem-solving, and technical abilities needed to succeed in a dynamic research environment.

To identify solutions for standardisation of education it would be helpful to indicate which institutions provide battery specialisation, the so-called 'battery hotspots'6 to analyse the situation by setting up working groups amongst graduate schools and universities in each Member State, to request verification bodies (for example, The European Quality Accreditation Commission) to assess annually the quality of education and the level of competence of trained personnel.

The public and private sectors should increase and consolidate their efforts in identifying future needs and defining adequate recommendations and incentives to the various stakeholders involved.

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4.4 Barriers of transformation

University rectors and deans need to change the current lengthy and laborious process of approving new curricula. There is reluctance of curricula defining bodies, from authorities, to adapt curriculum for middle education and vocational training, and from university departments for higher education levels. To identify curricula for battery education and skills training up to an acceptable level, a strategy should be implemented to alleviate the challenges with this process of curricula approval. Academia should recognise this situation and together discuss solutions to resolve the existing barriers. They should agree on a process to allow for a dedicated battery faculty. The public and private sectors together could support such initiatives.

On the industrial level, the challenges remain for the industrial permitting procedure which hinders the go-to-market time for battery material facilities. These slow processes could delay training as companies are reluctant to spend on training in the face of uncertainty of their facilities receiving full approval. Therefore, rapid upskilling solutions are needed for workers.

4.5 Training equipment

There seems to be a considerable lack of equipment and training labs where students would be able to carry out real-life, hands-on experiments, to complement the theoretical studies, hence acquiring a more complete knowledge and competency level2. The challenge is how to create interdisciplinary research curricula strongly connected with education through the entire Battery Value Chain. These curricula would then form a foundation that these training facilities could be built on.

An evaluation of the current situation on available training equipment in each Member State should be done to identify which kinds of investments are needed[31]. Such an approach would lead to a much smaller separation between industry/practical utilisation and academia, which is of the highest importance in this field. Building up pilot lines, demonstration, and training centres, etc., renewing old laboratory equipment, and allowing young students to access public and private production facilities will be crucial in the next few years. Facilities for research at Technology Readiness Levels (TRL) 5 – 6, or training facilities for vocational training at TRL 9 should be prioritised over facilities for research at TRL 2 – 3. The use of digital tools and virtual reality in training courses can help to improve the skills and knowledge transfer. This will also increase time flexibility which is a critical aspect when training is aimed at active workers.

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5 TRAIN THE TRAINERS/TEACHERS

5.1 The importance of skilled trainers for the battery sector

A functioning training and knowledge/competence transfer strategy has several interconnected parts. Trainers/teachers/mentors are a fundamental part of this system. The way they approach teaching is key to ensuring they successfully transfer knowledge and skills to their trainees/mentees/students. In addition to knowledge transfer, they are also responsible for evaluating and identifying training needs, normally in cooperation with companies and/or training organisations.

Besides being specialists in the scientific and technical areas, they need to possess other skills to adequately perform in their roles. Some of the most important ones involve pedagogic and presentation competences, which include but are not limited to, knowledge transfer, evaluation, development of teaching materials suited to the training purpose and training and presentation skills. At the European level, usually, those competences are taught and developed in specific training courses, either at the vocational or university levels. Normally the knowledge and expertise are taught in a generic way or aiming to train teachers of the elementary or medium formal education levels, not fitting the specific needs of any particular industrial sector. In many situations, as is the case for most university professors, no specific training occurs, and those skills are acquired by practice, an inefficient strategy as it may take too long and may lead to the acquisition of poor teaching practices.

As there is a strong need for skilled workers in all parts of the Battery Value Chain, there is also a strong need for trainers with knowledge and expertise in the sector. This is recognized by the EIT Raw Material report "Future Expert Needs in the Battery Sector"[2] which considers that "train the trainers" should consider the entire value chain and should be evolved to specific programmes.

Normally trainers are recruited/selected considering their expertise and experience in the battery sector, and previous experience of being a trainer. Pedagogical knowledge and skills to, for example, develop teaching materials or evaluate knowledge acquisition, are not normally considered vital to trainers, unless imposed by legislation or companies requiring trainers that be certified with these skills. This state of affairs is particularly seen in teaching at university level, where professors must also be researchers and are normally selected based on their research activities and results, not on their teaching capacities. These issues may limit the effectiveness of existing or future training activities in the battery sector. This, in turn, may limit the sector's future competitiveness and overall sustainability.

Presently there are some "train the trainer" initiatives in the European Union. The following non-exhaustive list offers examples of these training offerings, mostly delivered online:

- The ALBATTS (https://www.project-albatts.eu/) project has published 'A Handbook of Battery Teaching'. This is aimed primarily at vocational teachers.

- The European Battery Alliance Academy, which while focusing on the training and retraining of workers, also has some activities in training the trainers and course and competences certification[33].

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- Reed Courses: A UK-based online learning platform offering a well-structured TTT diploma with certification and learning paths.

- The Open College: An Irish e-learning platform offering TTT courses with QQI (Qualification & Quality Ireland) certification. However, there is a lack of training courses aimed specifically at the battery sector. Although there is some activity in this area, for example, ALBATTS has developed guidelines for train the trainers, much remains to be done. Hence, due to the relevance of these issues, a systemic approach is needed considering the various aspects which are listed below.

5.2 Need for evaluation of the current state of Train of the Trainers

There is currently no assessment of the current state of Train the Trainer offerings in the European Union. Without this, a definition of a strategy and policies to address the existing gaps cannot be meaningfully developed. Hence, the creation of an international commission/working group is recommended. A suggested title for this group is Batteries Europe Education Commission (BEEC), under the umbrella of Batteries Europe, or other collaborative platforms such as InnoEnergy. The function would be to assess the actual situation with recommendations for a path forward. The working group should include renowned specialists and representatives from all relevant stakeholders, in particular: universities/research centres, industry, recycling industry and battery suppliers, manufacturers and retailers. The progress of the working group should be overseen by a high-level board of specialists representing different European regions. Proper funding and support should be provided to the working group to achieve its goals.

Due to the urgent need for trainers the working group should produce a final report with recommendations and financing needs to be available Q1-2025. The report should present an evaluation of the current situation, considering but not limited to the following issues:

- Number of organisations, including high schools, graduate schools, universities, and vocational training centres, which have dedicated classes or courses on themes related or of interest in the battery sector;
- Number of teachers/lecturers/trainers involved, and their education levels and training certifications.
- Number of students involved, including gender representation.
- List of existing battery education programs, courses, and specialisations.
- List of European Calls, grants, and incentives to promote the acquisition of battery-related knowledge and competences, a list of collaborations between educational institutions.
- Description of training equipment available and its location. This should be complemented with existing Transnational Access schemes for accessing research infrastructure. E.g. Stories Project. https://www.storiesproject.eu/calls
- Identifying international and national standards and guidelines specifically aimed at battery education and/or training.
- Understand the level of public awareness given to the subject.
- Renumeration of teachers: how does this compare with other disciplines?
- Which verification bodies and/or certification schemes are in place?

Based on findings, the report should define a set of actions and/or good practices to improve the current situation to acceptable levels by 2030, as there is an urgent need of trainers in this domain.

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Some issues need immediate attention to train the highest number of people in short time. First, a diagnostic should be undertaken to identify the geographic distribution of battery competences and needs. It is essential to determine the "battery hotspots" determining where to initially focus. They may correspond to regions where gigafactories will or are being built, or areas with significant generation of spent batteries. The next step would be the development and implementation of pilot projects for training trainers also in those regions, with curricula tailored to their regional needs. The results of the pilot projects, in particular guidelines and teaching/training materials, should be made public, to serve as blueprints for the development of training programs in other regions adapted to specific settings. The development of these pilot projects should be combined, whenever possible, to the development and implementation of pilot lines aimed at training workers in battery manufacturing activities. The educational curricula should focus on the practical training of trainers and maximise dissemination and range of those activities. An emphasis should be given to digital training, for example using virtual or augmented reality, as it reduces the need for the trainees to leave the workplace.

5.3 Key aspects concerning trainer certification

Training certification relevant for Europe should take into account issues that are regional for battery training and issues that are broadly applicable across Europe. For example, only in a certain number of regions are there issues related to the extraction and processing of raw materials of cell and battery assembly relevant. However, there are key issues that are the same across Europe, for example, recycling batteries. Thus, trainers should be able to develop relevant skills regardless of the countries or regions where they are working, and the curricula and/or training activities should be developed with that goal in mind. This strategy will also ensure that a pan-European training corps is created.

The development and implementation of a certification scheme valid across the European Union will ensure a uniform and fair common ground for trainers across Europe, while guaranteeing standards in the competences that trainers must have. It is also important to certify training courses that may grant ECTS (European Credit Transfer and Accumulation System) credits.

The recruitment of certified trainers also increases the attractiveness of being a trainer, as it limits the market to those who invest in obtaining the certification. This benefits the industry as it requires the trainer to fulfil certain quality criteria, hence better results are expected from training activities. This certification should be renewed periodically, for example every five years, to ensure a renewal of skills in the battery sector, and to take into account the natural evolution of scientific and technological knowledge.

The BEEC should also be responsible for the definition of the certification scheme, in particular the requirements for certification or renewal of certification. The BEEC should upgrade the certification scheme periodically, considering not only the scientific and technical development in the battery sector, but also the evolution in pedagogic methods and new teaching instruments and methods. In addition, the BEEC, in collaboration with organisations at the national or regional levels (by delegation of competences for example), should take responsibility for certifying educational institutions, training centres, and research centres, among others; that may engage in training-the-trainers activities.

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5.4 Incentivising train in the trainer's initiative

Member States should encourage universities, graduate schools, training centres, professional/vocational training schools, and research centres to actively participate in and promote train the trainer activities, either by interacting with companies to address their specific training needs or by developing specific training courses. Specific funding and/or support should be provided by the Member States for training activities for the battery sector, integrated into specific support packages for the sector through competitive calls for proposals. These actions are particularly needed for university education and/or training, as universities normally respond slowly to changes in new areas and/or urgent needs from the industry, both at the regional and international levels.

5.5 The role of mentorship, tutoring and coaching

An additional method of developing training skills is mentorship, tutoring or coaching. Depending on the circumstances, specifically designed training may not be practical. For example, in the case of small companies installing battery systems, it may be a good option to transfer knowledge and competences regarding batteries through mentoring or tutoring. Coaching is also an option in larger companies. In particular, when compared to classroom training, it can be more effective, as there is a more direct relationship between trainer and trainee. However, time limitations and the unavailability of mentors and tutors can hinder the utilisation of this type of training, requiring specific funding or support for those activities.

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6 AWARENESS BY POLICY MAKERS AND GENERAL PUBLIC

6.1 Awareness by policy makers

Policy instruments can only be put into practice when there is broad understanding amongst policy makers and the public that battery skills and education is an issue that must and can be addressed.

To accelerate the implementation of educational and training programmes in the European battery sector, policy makers need to be aware of the policy actions that they can undertake and what the possible impact of these policies is. This chapter outlines several policy actions that could be taken on a European, national and regional level. Most actions will likely be suited to a regional level.

The strategies proposed for action at various levels—European, Member State, and Regional—aim to foster the development and utilisation of battery-related knowledge, skills, and infrastructure.

At the European level, initiatives focus on bolstering research and development infrastructure by encouraging cross-disciplinary knowledge transfer and supporting joint industry-academia programs. Additionally, advocating for curriculum standardisation across the EU, particularly in battery production, usage, and recycling is a priority. Efforts should concentrate on enhancing industry engagement by identifying needs and fostering researcher mobility through funding opportunities.

Furthermore, initiatives aim to enhance the attractiveness of the sector by stimulating collaborative efforts among early-career researchers and disseminating success stories and best practices via platforms at both national and regional levels.

At the Member State level, the emphasis is on developing vocational[34] programs tied to emerging battery facilities, including internships with dedicated funding. Continued analysis of necessary skills, alignment with industry requirements, and curriculum adaptation based on EU-wide standards, conform to Net Zero Industry Act[35], constitute key elements. Establishing learning labs, promoting diverse teaching methods, and fostering industry collaboration for standardised qualification programs are recommended strategies at this level.

At the Regional level, strategies focus on tailoring qualification programs to local industry needs while aligning with broader EU standards where possible. Moreover, the focus is on flexible learning methods, digital tool integration, and the establishment of regional educational networks concentrating on the Battery Value Chain. Additionally, creating validated pathways for career development, collaborative models between local industry and schools, and continuous training for educators are seen as crucial strategies.

The list above is non-exhaustive but could be used to help public officials at the various levels to find a set of policy initiatives that they can start, or join, to ensure that Europe has the workforce to realise the ambitions of the battery sector.

6.2 Awareness of the general public

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Public education on the positive impacts of batteries is instrumental in making the field more attractive for students and encouraging the re-skilling of workers[2]. By effectively communicating the significance of batteries in advancing sustainable technologies, addressing climate change, and driving innovation, public perception can shift positively. A well-informed public is more likely to recognise the crucial role batteries play in renewable energy storage, electric transportation, and overall environmental sustainability. This awareness can, in turn, inspire students to pursue careers in the battery industry and motivate workers to acquire new skills in this evolving field. While train the trainer, as mentioned in the previous chapter, will be useful, it is not enough, as many decisions about future careers or changes are taken at the dinner table and discussed with parents, partners, friends and family. As (future) employees will embark more on a trajectory of life-long learning, it is important that this happens in a wider society which embraces the battery sector as a net good for Europe which provides interesting and well-paying jobs.

To achieve this, the European Union can undertake the following tasks: launch comprehensive awareness campaigns emphasising the societal benefits of batteries, collaborate with educational institutions to integrate battery-related content into school curricula already at a young age, establish public learning labs to provide hands-on experiences, and offer grants to support initiatives that promote the positive aspects of battery technologies. Additionally, fostering partnerships with industry stakeholders for outreach programs and developing EU-wide standards for educational content can contribute to a more informed and motivated workforce in the battery sector.

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7 CONCLUSION

To conclude, several actions must be taken in the next few years to educate an increasing number of people with qualification profiles tailored to the industry's needs along the value chain. With proper coordination between individual Member States and by expanding current programmes the impact can be swift. To implement and coordinate all actions and skills and education level, coordination and support actions would be required to homogenise activities at all levels in various places. Subsequent actions for the broader roll-out will have to follow in the years after 2025.

7.1 Short-term recommendations: <2027

Prioritise funding on Education: EC should prioritise incentives for universities to cooperate more in education with main stakeholders to speed up the skilling and reskilling process which is urgent.

Skill Development: Urgent action is needed to bridge skill gaps and create a competitive workforce for the evolving battery industry through targeted training programs, education initiatives, and strategic partnerships.

Cross-disciplinary Education: Launch specialised courses urgently to address skill gaps in the entire Battery Value Chain.

Re-skilling Workforce: Prioritise re-skilling current industry workers, aligning their expertise with the demands of battery production.

Workforce Training: Emphasise rapid education and training to build a skilled workforce, boosting competitiveness globally.

Student Engagement: Implement mechanisms to attract students to battery-related subjects before their academic studies.

Vocational Training and Perception Change: Increase the attractiveness of the battery industry by prioritising vocational training and changing public awareness.

Focus on Vocational Training: Increase emphasis on vocational training, stressing experience in process scaling and cross-industry knowledge transfer.

Attractive Enhancement: Transform the perception of battery production into an opportunity, attracting local talent to strengthen the workforce.

Educational Standardisation and Public Awareness: Standardise education for researchers and bridge disparities and simultaneously educating the public on batteries for a sustainable future.

Standardise Curricula: Implement standardised Master-level curricula across Member States, supporting early-career researchers and addressing educational disparities.

Sustainable Future Education: Prioritise public education on the crucial role of batteries in building a sustainable future.

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Wider Educational Reach (both a priority in the short and long term): Expand the reach of education beyond academia to encompass the wider public, policymakers, and end-users, fostering awareness and acceptance of battery technologies.

Training and Education providers' Collaboration: Enhance practical skills through hands-on training, develop effective pedagogical methods, and foster collaboration for comprehensive workforce development through targeted initiatives and industrial partnerships.

Hands-on Training: Organise, with urgency, practical training sessions for trainers on pilot lines designed for educational purposes and realise specific centres spread in different geographic sites in Europe for this scope. Virtual Reality can be used to provide simulated experiences while there are not enough available pilot lines available.

Pedagogical Skills: Provide pedagogical training sessions for trainers, focusing on effective teaching methods and student engagement strategies.

University Engagement: Promote active participation of universities graduate schools and professional schools in tailored training activities, fostering collaborations with companies for dedicated course development.

Sense of Urgency: Today there is a serious lack of competent experts, and a significant gap for skilled technicians and engineers. These skills are much needed in many sectors in Europe, creating significant competition. This makes the urgency in the batteries domain even more apparent. An urgency aimed at every level of education to step up the efforts for enrolment, to start new and up-to-date courses, to find the lecturers to lead these programs, and to provide the necessary teaching infrastructure and equipment. At the same time, it must be highlighted that a close collaboration, hand-in-hand, between the education channels and the industry/business channels is desperately required. A more customised and cooperative type of education, stimulated by means of EU incentives, together with some kind of European curriculum for national adaption will help to close the gap for available skilled personnel in the marketplace.

7.2 Medium-term recommendations: 2027-2030

Workforces reskill: Scale up educational programs and create strong partnerships between academia and industry to meet the growing workforce demand with practical education experiences.

Workforce for Production: Expand educational programs proportionally to meet the growing demand for a larger workforce in the battery industry.

Holistic Education and Early Engagement: Prioritise holistic education with soft skills integration and engage students early on to prepare them for the dynamic demands of the battery industry.

Holistic Approach to Education: integration of cross-cutting transversal skills within training programs to effectively meet industry needs.

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Continuous Development and Certification System: Invest in continuous train the trainer programs and implement certification systems through workshops, seminars, and industry collaboration.

Guidelines for Training: Develop comprehensive courses or guidelines, like MOOCs, ensuring proper formation for training trainers in the battery sector.

Innovative Learning Paths and Collaborative Environments: Encourage innovative learning, interdisciplinary and collaborative research to enhance the educational experience in industry.

Interdisciplinary Research: Foster interdisciplinary research closely linked with the entire Battery Value Chain.

Mobility Programs: Increase mobility opportunities for students and trainers across different universities and companies enabling also the participation in internships within battery-related industries, emphasising the importance of gaining practical experience.

Use of Existing Programs: Use existing university and innovation centre programs.

Collaborative Learning: Promote collaborative learning environments among trainers to foster the sharing of knowledge.

7.3 Long-term recommendations: >2030

Innovative Training Models and Outreach: Use innovate training methods and models while expanding outreach efforts to various audiences, ensuring widespread awareness and acceptance of battery technologies.

Innovative Education Models: Explore cascade education, where younger students educate, to bridge the gap between trainers and those receiving the training.

Wider Educational Reach (both a priority in the short and long term): Expand the reach of education beyond academia to encompass the wider public, policymakers, and end-users, fostering awareness and acceptance of battery technologies.

Rapidly scalable training methodologies such as online training or blended learning should be commonplace. The training courses should be modular so that those can be modified, added more courses or omit obsolete courses as necessary.

Adaptability and Collaboration: Prioritise adaptability, collaboration, and partnerships with industry for a dynamic and practical approach to battery technology education

Continuous Adaptation: Ensure educational curricula evolve to incorporate emerging trends, including circularity, critical raw materials, and safe, sustainable battery design principles.

Industry-Academia Collaboration: bridge existing barriers between industry, academia, and schools, promoting knowledge transfer.

Partnerships with Industry: Foster collaborations between academic and public institutions and industry experts.

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Competency Building and Innovation: Focus on building competences, engaging in research, and fostering innovation, for cutting-edge battery technology education.

Competency Development: Build competences in large-scale cell manufacturing and associated areas like battery components, materials, recycling and automation.

Research Engagement: Encourage trainers to participate in research activities related to battery technology, aligning their knowledge with current trends.

Feedback Mechanisms: Establish feedback loops where trainers receive evaluations from students and peers to improve teaching methodologies.

Innovation Support: Encourage trainers to explore innovative teaching methods like flipped classrooms, MOOC, increasing the use of virtual reality and simulations for effective learning.

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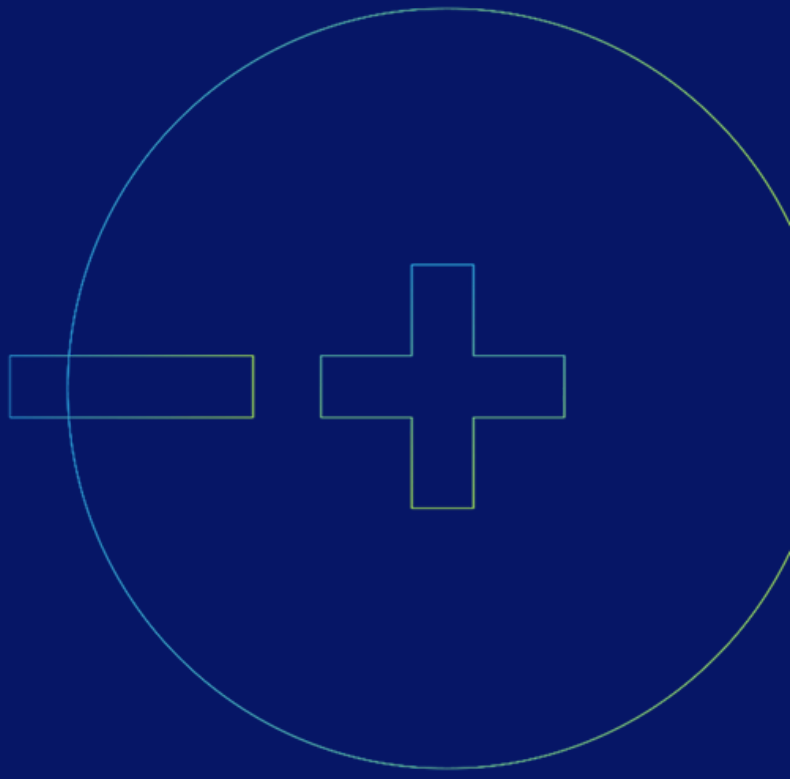

Contact us

www.batterieseurope.eu
info@batterieseurope.eu