InnoEnergy

Co-funded by the European Union

InnoEnergy Skills Institute

Powering the Transition to Net Zero Economies

A report on the talent and skills the Battery Industry will need

2023

Contents

Catalyst for change

Why building a skilled workforce for the booming Battery Value Chain is vital.

As more and more countries set ambitious targets for decarbonisation and sustainability on the road to a net zero economy, the demand for batteries and the introduction of innovative enabling frameworks for battery storage technologies will only continue to rise. The battery sector is growing exponentially and the resulting new job opportunities created is expected to number in the millions. Yet, to fully realise the potential of this rapidly expanding industry, a concerted effort is needed to develop the necessary skills and training for the workforce required to drive it.

Battery technology is a key enabler for climate-friendly mobility, as well as for maintaining grid stability following the increase in the share of renewable energy production. For example, the annual demand for lithium-ion (Li-ion) batteries around the world is projected to reach 4,700 gigawatt hours (GWh) by 2030.[1] This is a significant increase of more than six times the global usage figure of around 700 GWh in 2022.

Several Li-ion battery applications, primarily electromobility and stationary battery storage, are expected to fuel this demand. For example, the number of electric vehicles (EVs) on the road is forecast to grow elevenfold to 200 million by 2030.[2] While stationary storage installations worldwide are predicted to reach over 400 gigawatts (GW) by the end of 2030. This is 15 times the battery storage capacity online at the end of 2021.[3]

Of course, this growth will be conditional not just on the supply of materials but also on finding more skilled people to power it. And, as the battery industry's staffing needs escalate across the value chain, a cross-disciplinary approach is not only preferred but also urgently required.

[1] *Battery 2030: Resilient, Sustainable & Circular*, McKinsey & Company, 2023.

[2] *Global EV Outlook 2022*, IEA, Paris 2022.

[3] *Global Energy Storage Market to Grow 15-Fold by 2030*, BloombergNEF, 2022.

A race against time

Research conducted by EIT InnoEnergy Skills Institute over the past four years has identified more than 600 unique job profiles and skills across the battery value chain.[4] This incredibly diverse range of occupations encompasses the skills required to design, manufacture, maintain, troubleshoot and repair batteries for their different applications.

The research performed, and the results presented, in this compact report do not extend to 'soft skills' considerations such as teamwork, communication, project management, leadership, critical thinking, planning and organisation. Although, of course, these personal qualities help employees thrive in the workplace and are just as essential to success as the 'hard skills' being flagged for attention here.

As the sector booms there is an urgent need for employers and education and training providers to adapt quickly to the changes and new requirements. For instance, the rapidly expanding demand for Li-ion batteries gives rise to the need for additional job profiles skills across every link of the battery value chain – from raw materials and processing to battery cell and pack manufacturing to application and integration, recycling and second life.

In order to meet the capacity targets for 2030 (See Page 3), the industry needs to have the trained workers already in place today to be able to scale and deliver. This time pressure to have access to skilled workers is the biggest challenge facing the industry right now.

Some of the skills required to meet the demand are very sector specific, and relatively new, while others are non-sector specific and already prevalent in other industries such as electronics, pulp and paper, chemicals and pharmaceuticals.

Digital skills such as data analysis, data science, artificial intelligence, and software engineering are going to be even more highly sought after.

The EU workforce is generally regarded as highly qualified, although sufficient specialised battery-related knowledge and skills are still lacking across educational segments. In short, there's every indication that investment in specific training and upskilling programmes is essential if employers and education and training providers are to remain competitive in their respective sectors and keep up with the pace.

[4] Research conducted by EIT InnoEnergy Skills Institute (formerly EBA Academy), 2019-2023.

Analysis tools and methodology

Comprehensive analysis was undertaken to identify the job profiles and relevant skills required in the battery sector. Such as:

- **A literature review**: Reports relating to the industry, various sector initiatives and projects across the EU, together with research papers and articles.
- **Job listings review**: A close look at job listings relevant to companies active in the battery sector.
- **Expert panel insights**: Collected input from experts across the battery value chain via interviews, discussions and thought leadership pieces.
- **Software tools**: These help keep our data updated and allow for better understanding and visualisation of the information.

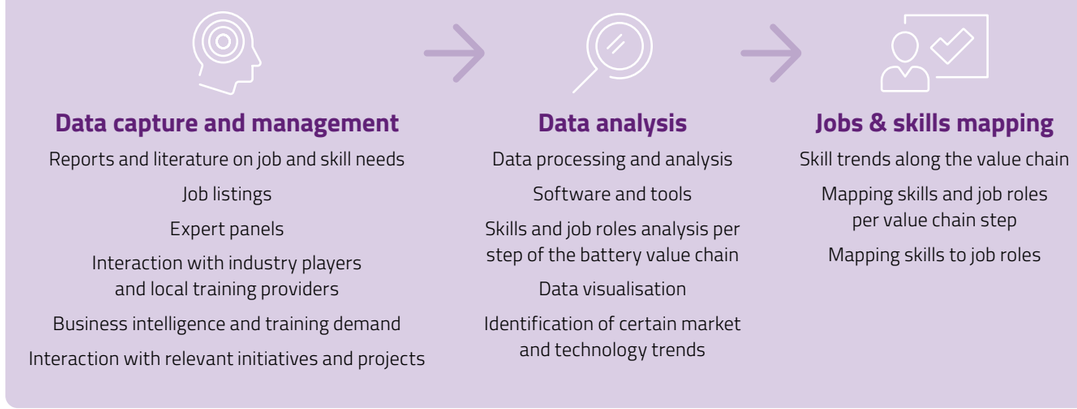
We have invested in

- an AI tool that allows us to follow updated and dynamic data on job profiles and skills, their urgency and growth in demand, as well as predicting the evolvement of future workforce requirements.
- a tool for mapping skills to job profiles and creating customised skills matrices.

The methodology we have defined for our skills and job profiles research includes the following steps (See Figure 1)

- **Data capture and management**: We begin with data gathering and consolidation from multiple sources. In addition to the literature and job listing reviews outlined above, and our continuous involvement and collaboration with the initiatives and projects across the EU, we strongly focus on industry needs and opinions. We interact with industry and local training providers to gather input and intelligence regarding training demands, identifying skill gaps, and predictions about upcoming job profiles.
- **Data analysis**: We then analyse the data regarding the job profiles and skills across the value chain as well as relevant trends. For example, as part of our analysis, we've looked into employment growth in a typical gigafactory in detail.
- **Job profiles and skills mapping**: We then proceed to map the job profiles and skills identified across the value chain, as well as map skills to specific job profiles. Based on this mapping, we're able to observe certain trends and extract insights that can be utilised for creating new content for learning.

Figure 1. **Skills Intelligence Methodology.**



Powering the global shift towards net zero economies

The battery value chain consists of four main steps (See Figure 2): Raw materials & Processing, Battery cell & Pack manufacturing, Application & Integration, and Recycling & Second life.

In the initial stage of raw materials and processing, roles such as sourcing analysts, laboratory technicians, mining engineers, material handlers, Research & Development (R&D) engineers, and battery material engineers are essential. They are responsible for sourcing and processing raw materials that meet current industry requirements and identifying new materials to meet future market demands.

Depending on the role, these profiles require knowledge and experience in working with electrode materials, chemical engineering, and safety, together with skills in extraction and refinement, and characterisation techniques.
Battery production plays a pivotal role in the global energy transition to smart electrification.

In the second stage of the battery value chain, cell and battery pack manufacturing, professionals like process engineers, battery design engineers, manufacturing engineers, quality and test engineers, production technicians, calibration technicians, and maintenance technicians are vital. They design, assemble, test, and ensure battery quality.

Skills required for these profiles include automation, battery cell design, high speed mechanical assembly, battery handling, electrical safety, electrochemistry, preventive and predictive maintenance, quality control, battery testing, failure mode and effect analysis, among others.

For purchasing cost-effective components according to demand, profiles such as purchasing analysts and logistics managers are required. The main skills in this regard include battery supply chain and logistics processes, the purchasing of battery components, material flows, and knowledge of relevant regulations and safety procedures.

Presently, approximately 1 million individuals are employed in similar job profiles supporting the EV battery value chain, with China having the largest share[5].

The transition to green energy and net zero economies will necessitate battery manufacturing expansion to other regions to match growing integration and application demands for diverse battery technologies.

This step of the value chain demands specialised skills for effectively integrating batteries into specific applications, such as EVs and behind-the-meter storage, as explained later in the report.

The final stage of the battery value chain concentrates on battery reuse, repurposing, and recycling.

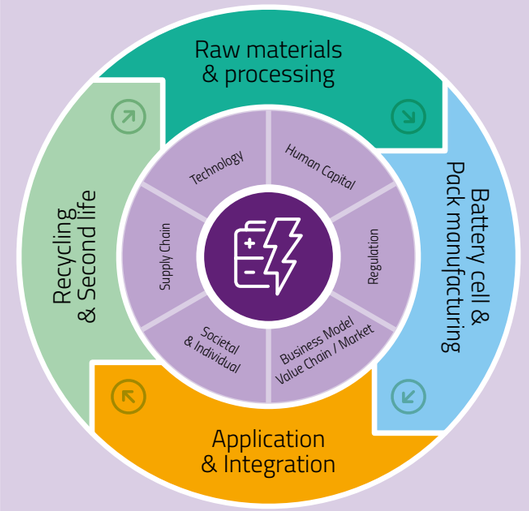
For reuse and repurposing, proficiency in regulatory frameworks, safety standards, performance evaluation through data analysis, and refurbishment techniques is crucial.

The recycling stage requires a deep understanding of relevant regulatory frameworks, as well as expertise and sustainable practices in material recovery techniques to efficiently extract materials and minimise hazardous waste.

Further elaboration is provided later in the report.

[5] *World Energy Employment Report*, IEA, 2022

Figure 2. **Stages of the Battery Value Chain.**



Rise of the gigafactories

'Gigafactories' are considered a hot spot for in-demand skilled workforces. It's a generic term for a manufacturing facility specialising in products and components associated with electrification and decarbonisation technologies. In the EU, it is estimated that approximately 800,000 workers will need to be trained, reskilled or upskilled by 2025 to meet rising demand in battery cell and module production.[6]

As part of our research, we have also closely analysed the employment growth in a gigafactory.

Within a gigafactory, approximately 85% of the workforce required represents the downstream manufacturing process (electrode manufacturing, cell assembly, cell finishing), while the remaining 15% represents the upstream manufacturing process (active materials production, chemical processes). Out of an average of 80 to 120 direct jobs/GWh, approximately 75-80% of the workforce is blue collar.

When you consider additional indirect jobs, this increases significantly to around 300 to 1,400 indirect jobs/GWh. Take into account the downstream value chain and this figure can be multiplied 5 to 10 times more.

Looking at the employment growth of a 'typical' 30 GWh gigafactory with an average 90 full-time employees per GWh, we can extract certain levels of information across the stages ranging from planning and construction to full capacity.

At the early stages of the gigafactory the 'top layer' is employed, typically comprising specialists already in this area, often from abroad. As time progresses more production staff are hired, and it's important to highlight that the hiring process occurs months prior to the staffing requirement in many cases. This depends on past experience, the need for reskilling or upskilling, as well as the on-the-job training considerations.

Once the production process is fully established, there is a greater need for vocational workers such as technicians and operators.[7][8][9][10][11]

[6] *Launching the European Battery Academy to reskill thousands of industry workers*, European Institute of Innovations & Technology (EIT), 2022.

[7] Research conducted by EIT InnoEnergy and InnoEnergy Skills Institute (formerly EBA Academy), 2019-2023.

[8] *Future Expert Needs in the Battery Sector*, Fraunhofer, EITRawMaterials, 2021.

[9] *Task Force Education and Skills Position Paper*, Batteries Europe, 2021.

[10] *The First Shift at Northvolt Ett*', Northvolt, 2021.

[11] *UK Electric Vehicle and Battery Production Potential to 2040*, The Faraday Institution, 2022.

Battery industry expansion and electromobility demand

The integration of batteries, in general terms, requires sector specific skills to effectively integrate them into specific applications ensuring compliance, safety and optimal performance. These skills include, among others, knowledge of battery technologies, battery management and control, battery management systems, integration optimisation, specifications for specific applications, and working with electrical and electronic systems.

Looking into the application of batteries, there is a focus on electromobility and stationary storage. Electromobility occupations include automotive engineers, battery system engineers, algorithm and software engineers, functional safety engineers and system control engineers. There are also production assembly operators and battery maintenance and test technicians. These profiles require extensive knowledge and experience of working with batteries for electric vehicles, and with battery management systems, all the while adhering to stringent safety standards.

Automotive engineering, EV battery design and diagnostics, maintenance, servicing, and experience in performance prediction are specialised duties that also form part of the growing EV employment spectrum.

It's therefore no surprise that the International Energy Agency (IEA) estimates that around 7 million people could potentially shift from internal combustion engine (ICE) vehicle manufacturing to electric vehicle manufacturing.[12]

Apart from location and manufacturing differences that would need to be overcome, there are certain synergies between the ICE and EV industries that make the potential utilisation of existing manufacturing facilities a logical and likely move.

[12] *Energy Technology Perspectives 2023*, IEA, 2023.

Battery storage systems set to surge worldwide

In stationary storage applications, battery systems engineers, application engineers, data and software engineers and quality and installation technicians are needed to design, test, install, and ensure the quality of battery storage systems behind-the-meter as well as in-front-of-the-meter. These profiles require knowledge and experience with battery components, system design and integration, battery management systems, as well as diagnostics, performance prediction and electrical safety.

Some 70,000 Americans already work in the battery storage systems sector, and this number is likely to see a five to six-fold increase.[13] If the growth of battery storage systems continues, there will be a need for well over 1 million new jobs by 2030 globally, many of them in Europe and America.

All in all, there's an unprecedented need for the hands, hearts, and brainpower of skilled workers to make the most of the opportunities in the battery industry, and its two main downstream value chains.

Figure 3 provides an example skills matrix for the profile of a battery systems engineer and quality technician (integration). It lists the relevant skills and knowledge required and is separated into groups: battery systems, digital skills, engineering, quality and testing, and safety. Each skill or knowledge base is represented by a pie chart that specifies the level required to perform the job. For example, a battery systems engineer needs to possess an advanced level of electrical engineering knowledge and experience. This example is an extract from a report that we provide our customers help them match the skillsets with individual job profiles.

Skill Level Classification

Awareness: The employee requires a fundamental awareness or basic knowledge of this topic. Knowledge and theory related to this topic might be applied to a task.

Novice: The employee requires limited experience in this topic and would require help while applying this knowledge or performing this skill.

Intermediate: The employee requires intermediate experience in this topic and is able to successfully complete a relevant task occasionally. Assistance or guidance from an expert might be required at certain stages.

Advanced: The employee requires advanced experience within this topic and can perform relevant tasks without assistance and is capable of assisting someone with less experience.

Expert: The employee is an expert in this area and can perform tasks within this topic without any assistance with mature and practiced understanding. The employee is not only able to answer questions related to this topic and provide assistance to someone with less experience but is also capable of teaching others on this topic.

[13] *Nearly 70,000 Americans employed by battery storage industry in 2021,* Energy Storage News, 2022.

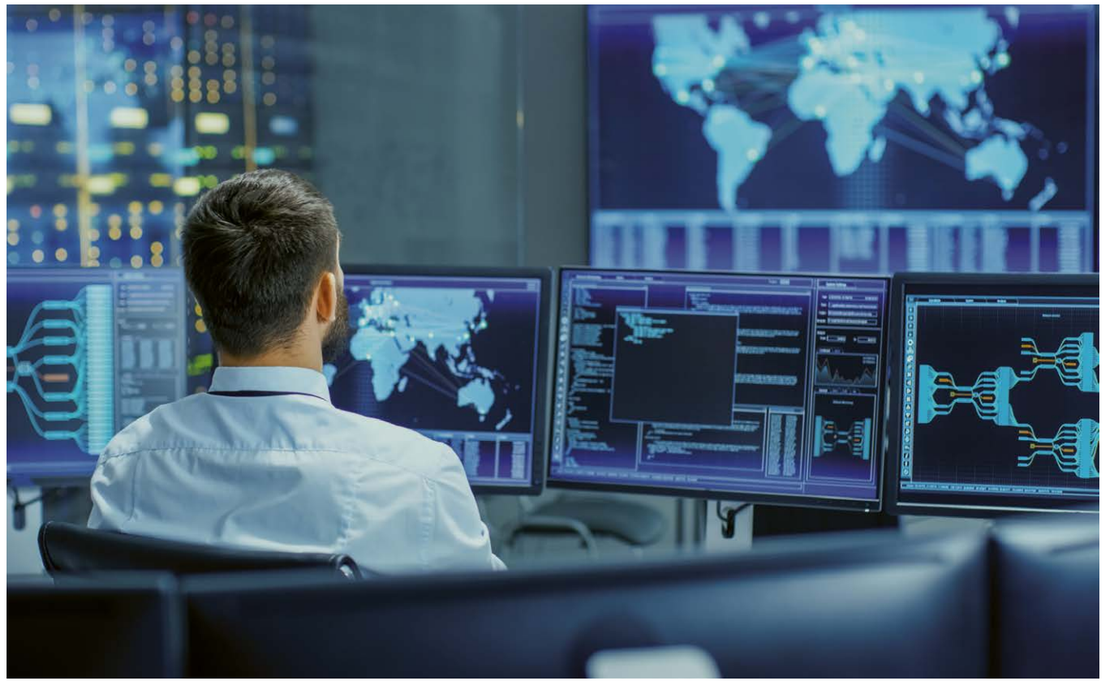
Figure 3. **Example skills matrix for a battery systems engineer and quality technician (integration).**

It is important to specify that the graph does not necessarily highlight the level of skills or knowledge required during the hiring process, as some of these skills can be acquired or improved via re/upskilling and on-the-job training.

Sustainable futures. New profiles in battery recycling

The final section of the battery value chain is dedicated to battery recycling and second life. Key occupations include recycling specialists and engineers, environmental engineers, chemical engineers, machine operators, recycling, R&D, and inventory technicians. All these job profiles are needed to implement efficient and environmentally friendly processes to recycle and reuse batteries.

Knowledge and experience required in this part of the chain extends to battery components and materials, chemical engineering, material science, material recovery, and relevant regulations. Further skills called upon include dismantling batteries, handling of hazardous waste, and battery upcycling – such as repurposing EV batteries for stationary applications.



Addressing the brainpower shortage

Reflected in the job profiles and required skills listed in this report, is the need for both skilled workers as well as innovative and forward-thinking individuals in the battery industry.

To grow a workforce that meets this need at the rapid pace the industry demands, it is important to provide multiple opportunities for training and upskilling. The current shortage of skilled workers in the battery sector is a major challenge that threatens the growth and sustainability of the industry.

The urgency of growing and upskilling this workforce cannot be overstated, and steps must be taken now to address this problem. Employers need to invest in training and upskilling their existing workforce, while learners must be encouraged to pursue careers in the battery sector.

InnoEnergy Skills Institute is continuing to monitor the battery sector and its workforce and training needs, allowing for updated information on job profile and skill needs across the value chain and already has a portfolio of over 400 learning hours, actively training the workforce today in collaboration with other projects and initiatives aimed at supporting these efforts.

At InnoEnergy Skills Institute, we specialise in providing workforce insights tailored to your needs. If you're interested in learning more about the findings from our research or accessing a comprehensive list of face-to-face training opportunities and online education programmes, we're here to assist you.

As industry experts, we offer consultation services and can provide you with a detailed report (Skills Compass) outlining the specific skill sets required for in-demand job profiles.

Contact us today to initiate a discussion regarding your unique requirements and gain access to invaluable insights and resources that will drive your business forward.

www.innoenergy.com/skillsinstitute/contact

Job profiles required in the Battery Value Chain[14]

Figure 4. **Summary of required job roles in the battery value chain.**

Raw materials and processing

- Advanced purchasing analyst
- Battery material engineer
- Battery material technician
- Business Controller
- Calibration technician
- Cleanroom engineer
- Data scientist
- Environmental analyst
- Equipment engineer
- Equipment technician
- Inventory technician
- Laboratory technician
- Material handler
- Mining engineer
- Quality control engineer
- Raw materials sourcing analyst
- R&D engineer
- Safety manager
- Supply chain analyst
- Technical manager

Cell and battery pack manufacturing

- Battery software engineer
- Calibration technician
- Compliance manager
- Data scientist
- Design engineer (Battery)
- Engineering manager
- Health and safety manager
- Logistics manager
- Maintenance technician
- Manufacturing engineer
- Manufacturing operator
- Operations manager
- Plant shift leader
- Process engineer
- Production technician
- Purchasing analyst/specialist
- Quality engineer
- R&D engineer
- Systems design engineer
- Test engineer

Electromobility

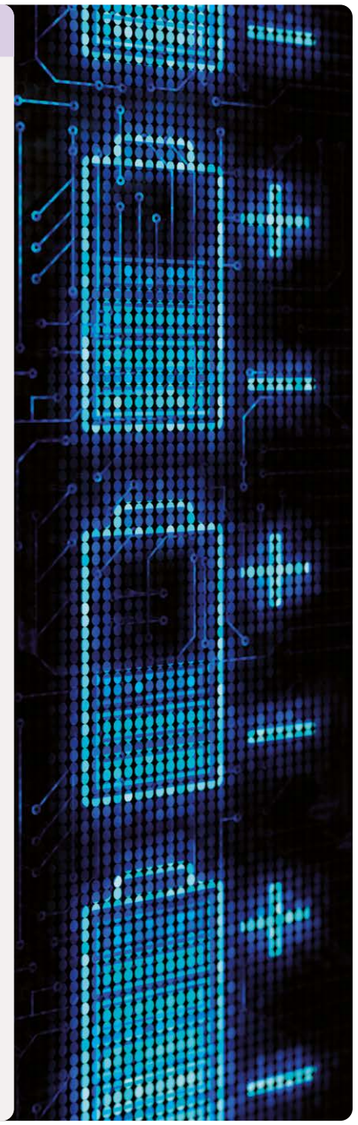
- Automotive engineer
- Automotive safety performance engineer
- Battery Algorithms Engineer
- Battery maintenance technician
- Battery management systems engineer
- Battery system engineer
- Compliance manager
- Design engineer
- Electric vehicles service technician
- Engineering technician
- Equipment technician
- EV Sales manager
- Functional safety engineer
- Lab engineer
- Production assembly operator
- R&D engineer
- Safety engineering technician
- System controls engineer
- Test technician
- Vehicle testing & operations manager

Stationary storage applications

- Application engineer
- Battery Analytics Data Scientist
- Battery algorithms engineer
- Battery system engineer
- BESS service technician
- Commissioning Engineer
- Compliance manager
- Controls engineer
- Data engineer
- Electrical engineer – BESS
- Embedded systems engineer
- Environmental analyst
- Innovation manager
- Installation technician
- Maintenance manager
- Mechanical Design Engineer
- Operations manager
- Quality technician
- Software engineer
- System design engineer

Battery recycling / Second life

- Battery materials technician
- Battery recycling specialist
- Chemical engineer
- Compliance specialist
- End of warranty manager
- Environmental engineer
- Health and safety specialist
- Inventory technician
- Machine operator
- Metallurgist
- Process operator
- Project engineer - Battery second life
- R&D scientist
- R&D technician
- Recycling collector
- Recycling process engineer
- Recycling technician
- Service technician
- Technical lead recycling
- Warehouse operations supervisor



[14] EIT InnoEnergy and InnoEnergy Skills Institute (formerly EBA Academy) research and interviews with battery stakeholders (2018-2023), *ALBATTS reports* (2019-2023), *Future Expert Needs in the Battery Sector* (2021), *Batteries Europe Task Force on Education and Skills Position Paper* (2021).

Skills required in the Battery Value Chain[14]

Figure 5. **Summary of required skills in the battery value chain.**

Raw materials and processing

- Anode and cathode materials
- Automation in mining
- Battery materials
- Characterisation techniques
- Chemical engineering
- Chemical safety
- Data analysis
- Environmental management
- Machine handling
- Material refinement
- Materials science
- Measurement and control
- Raw material extraction
- Sourcing
- Supply chain management

Cell and battery pack manufacturing

- Battery chemistries and technologies
- Battery design
- Battery handling and electrical safety
- Battery manufacturing process
- Battery testing and quality control
- Cell design
- Clean & dry room processes
- Data science
- Electrochemistry
- Failure analysis
- Preventive and predictive maintenance
- Quality control and inspection
- Root cause analysis
- Software engineering
- Troubleshooting

Electromobility

- Automotive engineering
- Battery management systems
- Data analysis
- Diagnosis of defects in EVs
- Drivetrain components
- Electrical safety
- EV battery design and chemistries
- EV battery maintenance and servicing
- EV homologation and testing
- Failure analysis
- LV and HV battery systems
- Performance prediction
- Safety standards
- Software engineering
- Troubleshooting and repair

Stationary storage applications

- Battery components
- Battery management systems
- Battery system design and integration
- BESS installation
- Data analysis
- Diagnostics
- Electrical safety
- Equipment and tools handling
- Failure analysis
- Grid and off-grid applications
- Performance prediction
- Power electronics
- Monitoring and control
- Safety standards
- Troubleshooting and repair

Battery recycling / Second life

- Battery design and components
- Battery dismantling
- Battery materials
- Chemical engineering
- Data analysis
- Environmental management
- Hazardous waste handling
- Inventory control
- Material recovery
- Material science
- Process engineering
- Quality control
- Recycling equipment handling
- Reuse and repurposing of batteries
- Safety standards and regulations

[14] EIT InnoEnergy and InnoEnergy Skills Institute (formerly EBA Academy) research and interviews with battery stakeholders (2018-2023), *ALBATTS reports* (2019-2023), *Future Expert Needs in the Battery Sector* (2021), *Batteries Europe Task Force on Education and Skills Position Paper* (2021).

Supercharged upskilling and reskilling services from the InnoEnergy Skills Institute

The InnoEnergy Skills Institute is one of world's leading training skills providers for the sustainable energy workforce, spanning energy storage, photovoltaics, and green hydrogen. It was established to address this industrial challenge, building a project-driven community of more than 800 key players in industry and innovation, ranging from mining to recycling.

Inspired and informed by the dynamic clean energy ecosystem of EIT InnoEnergy, we equip the global workforce with the expertise and skills required to create a sustainable economy, distilling our unrivalled knowledge and know-how into relevant, applicable, and effective modular training courses and credentials.

So far, the institute has trained and upskilled over 40,000 workers and delivered more than 35 courses and programmes in over 10 languages. Our agility and expertise transform the skills of today's workforces into those needed for a clean tomorrow.

Please visit **www.innoenergy.com/skillsinstitute** for further details.

Contributor credits

InnoEnergy Skills Institute

Main author: Dimitra Maleka, Energy transition skills expert.
Dimitra Maleka completed a Diploma in Mechanical Engineering and a Master of Science in Sustainable Energy Engineering. She is currently working as an Energy Transition Skills Expert at InnoEnergy Skills Institute and leads the skills intelligence research related to electrification. Dimitra is also acting as a task leader in the Batteries Europe Task Force on Education & Skills and has been actively involved in several other EU initiatives in related areas.

Review and revision: Ashley Gyllen, Head of Learning Research at InnoEnergy Skills Institute.

Additional support: Kris Ignaciuk, Energy & Climate specialist at IGN Research and Advisor to InnoEnergy Skills Institute.

Co-funded by the
European Union

InnoEnergy Skills Institute
Kennispoort 6th floor
John F. Kennedylaan 2
5612 AB Eindhoven
The Netherlands
info@innoenergy.com

EIT InnoEnergy is the trading
brand of KIC InnoEnergy SE

www.innoenergy.com/skillsinstitute