BATPOWER
Preparation of the VET sector on battery energy transition

BatPower: Preparation of the VET sector on battery energy transition

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COMPANIES

ACTIVITIES

Describe the company's activities in battery technologies.
The companies interviewed operate across different stages of the battery value chain, reflecting the diversity of industrial specialisation in each country. In Italy, MIDAC represents a well-established industrial actor specialised in the **design, production and recycling of lead-acid and lithium-ion batteries**, particularly for industrial and automotive applications. The company is strongly engaged in research and development activities related to **battery innovation, safety, and recycling processes**, and is progressively integrating automation and digitalisation into its manufacturing operations. In Spain, the interviewed companies include battery producers and integrators engaged in **developing storage systems and mobility solutions**, as well as companies involved in **battery maintenance and energy efficiency services**. Activities focus on the application of lithium-ion technologies, energy management systems, and battery diagnostics, with a particular emphasis on **sustainability and circularity**. In Hungary, the companies are mainly large industrial players and suppliers operating within **battery manufacturing gigafactories**, often as part of multinational groups. Their activities span from **cell production and module assembly to system integration and testing**, including partnerships with global automotive firms. Due to their scale and international linkages, these companies often apply **cutting-edge technologies and comply with high-quality production standards**. n **Slovakia**, the interviewed company **InoBat** specializes in research, development, and manufacturing of advanced lithium-ion battery cells. It operates a cutting-edge R&D center and pilot production facility in Voderady, with plans for scaling up to a full gigafactory. InoBat focuses on customising battery cell design and chemistry for various applications (automotive, aerospace, energy storage), covering the full battery lifecycle—including recycling and second-life use—within a circular economy approach. Across all countries, companies are increasingly embedding sustainability, digitalisation, and innovation into their operations and engaging in partnerships with research centers

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and educational institutions to support workforce development and technological advancement.

HARD/SOFT SKILLS

Which hard and soft skills are most important and critical in the sector and which areas should be targeted for training investment?
Across all four countries—Italy, Spain, Hungary, and Slovakia—companies consistently emphasised the importance of a dual set of competencies: **technical (hard) skills directly related to battery manufacturing and diagnostics**, and **soft skills essential for working in multidisciplinary, fast-evolving environments**. **Hard skills identified as critical:** • **Battery Chemistry and Materials Science**: Understanding of lithium-ion technologies, materials selection, and ageing mechanisms (reported notably in Slovakia and Italy). • **Battery Management Systems (BMS)**: Competence in using and interpreting BMS and diagnostic software (Spain, Slovakia, Hungary). • **Assembly and Quality Control Procedures**: Skills in precision assembly of battery modules, defect detection, and compliance with industry standards (Hungary, Slovakia, Italy). • **Electrical Safety and High-Voltage Handling**: Essential for safe operation in manufacturing and maintenance contexts (Italy, Spain). • **Data Interpretation and Sensor Use**: Ability to interpret sensor outputs for testing and monitoring (Slovakia, Spain).

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- **Automation and Robotics in Production**: Familiarity with automated assembly lines, especially in gigafactories (Hungary, Italy).

Soft skills emphasised:

- **Problem-Solving and Critical Thinking**: Needed for fault diagnosis, innovation, and continuous improvement (common across all countries).
- **Adaptability and Learning Agility**: Particularly important due to the rapid evolution of technologies and processes (Slovakia, Hungary).
- **Communication and Collaboration**: Ability to work in cross-functional teams and communicate technical issues clearly (Italy, Spain).
- **Attention to Detail and Safety Culture**: Especially relevant for quality assurance and risk prevention (Slovakia, Hungary).
- **Project Management and Responsibility**: Basic organisation, task management, and awareness of production timelines (Spain, Italy).

Training investment priorities:

- **Hands-on training with real equipment and lab environments**
- **Short-cycle upskilling courses focused on specific battery-related tasks**
- **Simulation and digital tools for diagnostics and testing**
- **Dual-learning pathways combining theoretical instruction and workplace learning**

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- **Transversal modules to develop problem-solving, teamwork, and digital literacy**

These findings highlight the urgent need to bridge the gap between existing VET curricula and the complex, evolving skill set required by battery sector employers. The priority is not only to build technical knowledge but also to foster flexibility, safety awareness, and interdisciplinary collaboration.

TRAINING PROCESS

Explain the training processes in the companies interviewed and what kind of investments they make. Indicate any training tools or content that can be used in the project.

The companies interviewed across Italy, Spain, and Hungary demonstrate **varying levels of investment in training**, generally depending on their size, internal resources, and degree of technological advancement. However, a common trend is the growing awareness of the need to **strengthen internal learning pathways** to cope with rapid innovations in battery technologies.

In **Italy**, companies like MIDAC emphasise the importance of **on-the-job training** supported by internal trainers and mentors. Investments focus on:

- **Continuous technical updates** related to chemistry, automation, and recycling
- Involvement in **national and regional training programmes**
- Participation in **technical committees and standardisation bodies**, which serves as a source of updated knowledge
- Internal sharing of knowledge between R&D and production departments

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In **Spain**, larger companies develop **in-house training academies**, offering structured learning programmes aligned with company strategies. Notable investments include:

- Development of **customised learning platforms**
- Use of **digital training tools and simulators**
- Stronger collaboration with VET centres and universities to align content with real industry needs

In **Hungary**, while some multinational companies provide **structured onboarding and safety training**, many local firms report **limited capacity** for systematic training. However, where possible, they invest in:

- Short technical courses on battery maintenance and electrical safety
- Internal knowledge transfer from experienced technicians
- Collaboration with universities to access R&D training modules

In **Slovakia**, InoBat has developed a structured training process that includes:

- **Internal onboarding and peer-to-peer training**
- **Modular in-house courses** on chemistry, safety, diagnostics, and automation
- **Collaborative development of a national "battery technician" qualification profile**
- **Participation in EU-funded retraining schemes**

InoBat's materials—especially those related to high-voltage safety, testing protocols, and hands-on procedures—represent valuable input for the project's training module design. The company also supports the adaptation of training content for VET use and promotes micro-credentialing strategies.

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Training tools and content that could be adapted for the project include:

- Safety and diagnostic checklists from industrial environments
- Case studies on battery component failures and quality assurance
- Micro-modules developed with or by companies on BMS, safety, and lifecycle
- Internal visual SOPs and simulation tools used in onboarding
- Mentorship and peer-learning formats adapted from company settings

Overall, companies express interest in the co-development of **modular training content** that can be reused internally and shared with education providers. They support the idea of combining **technical content (e.g. battery components, safety procedures, quality standards)** with **practical training methods**, such as case-based learning and virtual demonstrations.

COLLABORATIONS

Indicate what kind of synergies and collaboration methods are established between the company and training institutions, highlighting critical issues and positive aspects.

The companies interviewed across Italy, Spain, Hungary, and Slovakia demonstrate varying degrees of collaboration with educational institutions, reflecting national differences in training systems and industrial maturity. However, several shared patterns and challenges emerge.

In **Italy**, the collaboration between companies and VET institutions remains mostly informal or project-based. While companies like MIDAC are open to engaging with schools and training providers, structural partnerships (such as dual training schemes) are still limited. The most common forms of synergy include:

- Hosting technical visits or internships

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- Participating in curriculum co-design (occasionally)
- Offering expert talks or seminars

Positive aspects: Interest in co-creating targeted training paths and willingness to share industry know-how
Critical issues: Lack of shared tools, limited continuity, weak institutional coordination, and time/resource constraints on the company side

In **Spain**, collaboration is more structured thanks to the dual VET system and regional innovation hubs. Companies routinely:

- Host apprentices and VET students for long-term placements
- Co-develop training content with public training centres
- Share labs and equipment under regional agreements

Positive aspects: Strong public-private ecosystem and alignment with local industrial needs
Critical issues: Fragmentation among regions and variable quality of institutional capacity

In **Hungary**, partnerships are emerging but still fragile. Companies collaborate mostly with universities, offering:

- Guest lectures
- Joint thesis supervision
- Technical seminars or site visits

Positive aspects: High motivation from companies to influence curricula
Critical issues: Dual VET not yet fully functional; low penetration of real workplace experience in VET; lack of practical facilities in schools

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In **Slovakia**, **InoBat** engages in a comprehensive set of collaborations with both VET and higher education institutions. These include:

- Development of a formal VET qualification profile for battery technicians
- Joint participation in EU-funded retraining projects
- Hosting internships, shadowing programs, and factory learning experiences
- Active involvement in shaping national training strategies

Positive aspects: Long-term vision, embedded collaboration in training system, strong commitment to talent development
Critical issues: Misalignment between academic calendars and industrial timelines, lack of hands-on labs in schools, administrative burden for SMEs to engage

Common positive aspects across all contexts include:

- Increased student exposure to real industrial environments
- Opportunities to shape training content through industry input
- Shared interest in supporting local talent pipelines

Critical issues include:

- Fragmentation of collaboration efforts
- Slow curriculum update procedures
- Limited incentives for companies to invest in training partnerships

Overall, while collaboration exists and is valued, it needs to be **more structured, continuous, and mutually beneficial**, especially to address the skills required in the rapidly evolving battery technology sector.

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CONCLUSION

Provides practical examples of elements related to training (content, tools, equipment, models of collaboration with training institutions and/or other organisations or case studies) that were highlighted by interviewees.

The interviews revealed a variety of practical training-related examples across companies in Italy, Spain, Hungary, and Slovakia, ranging from internal technical content to external collaborative models with schools, universities, and public initiatives. These examples provide inspiration for replicable practices within the BATPOWER training framework.

Italy – MIDAC

- **In-house training materials** on battery diagnostics, assembly, and safety procedures, delivered by experienced technical staff.
- **Use of real production environments** to train new hires and upskill current employees on quality assurance processes.
- **Participation in joint research and innovation projects** with universities, where results are gradually fed back into internal training.

Although collaboration with schools is still limited, MIDAC expressed interest in opening its facilities for **guided training experiences** and **co-designed curricula**.

Spain – Battery integrators and energy service providers

- **Dual VET programmes** offering structured internships with direct supervision, using **company equipment and tools**.
- **Development of micro-modules** on battery safety, BMS and energy efficiency, co-created with public training centres.
- **Case-based learning materials** derived from real battery system failures, used for classroom discussion and simulation exercises.

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- Collaboration with regional mobility hubs (e.g. MUBIL) to offer **shared lab access** and sector-specific teacher training.

Hungary – Large-scale battery manufacturers

- Use of **digital SOPs** (standard operating procedures) and safety videos during onboarding.
- On-site **technical micro-trainings** covering welding, assembly, and defect detection methods, which could be simplified for VET use.
- **Guest lectures and thesis mentoring** in partnership with local universities and engineering schools.
- Need expressed for **standardised content** in Hungarian for students and trainers, particularly on new chemistries and diagnostics.

Slovakia – InoBat

- **Creation of a national qualification profile** for "battery technician", in cooperation with the Ministry of Education and VET institutions.
- Internal training modules on **battery chemistry, safety, quality control, and automation**, designed with modular logic and adaptable to external learners.
- **Shadowing and mentoring programmes** for VET students and young graduates, integrated into production teams.
- Participation in EU retraining projects, contributing **training content and test protocols** related to diagnostics and high-voltage safety.
- A pilot **battery testing lab** where young technicians can access real measurement instruments (e.g. EIS, BMS simulators).

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These examples confirm that companies possess a wealth of relevant training content, tools, and models that—if made accessible and appropriately adapted—could significantly enrich vocational training. Several firms have also expressed willingness to share materials or co-create learning units, highlighting strong potential for public-private cooperation in the design of modern battery education pathways.

EDUCATIONAL INSTITUTES

ACTIVITIES

Describe the training activities in battery technologies.
The training activities in battery technologies across the interviewed educational institutions are still emerging and vary in scope and depth depending on the country and type of institution. In **Italy**, battery technologies are addressed primarily within university-level programs focused on sustainability, innovation management, and green transition. For example, LUISS integrates battery-related content into Master's programs such as the Master in Green Management, which explores battery innovation as part of sustainable business models. The focus is not limited to technical knowledge but includes legal, economic, and environmental aspects, promoting a multidisciplinary perspective. In **Spain**, several universities and VET centres are actively working to embed battery-related topics into their curricula, particularly in regions with strong industrial investment (e.g., Catalonia, Basque Country, Valencia). Training includes modules on lithium-ion batteries, electric mobility, and energy storage, often developed in collaboration with local gigafactories and battery producers. Some VET centres provide hands-on training supported by regional innovation hubs or battery campuses. In **Hungary**, while higher education institutions (e.g., universities of technology) offer research-oriented programs on battery development and energy storage, VET institutions

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are beginning to include content on battery systems maintenance, safety, and charging infrastructure, albeit with limited resources. The focus is mostly on aligning VET education with industrial needs in electromobility. In **Slovakia**, the DSA provides structured training through dual education models, combining classroom instruction with company-based learning. Battery topics are integrated into electronics and mechatronics training programmes. In cooperation with industry, they are currently contributing to the development of a national VET qualification standard for battery technicians, which will include core modules on battery components, safety, and diagnostics. Training activities emphasise practical skills acquisition, peer mentoring, and company-based internships. Overall, the training activities identified show a clear effort to integrate battery-related knowledge, although a comprehensive and standardized approach at the VET level is still under development. Most training remains fragmented or embedded in broader topics such as sustainability, green mobility, or electrical engineering.

TRAINING PROCESS

How are training courses defined? Who is the target audience?
Training courses in battery technologies are defined according to the institutional mandate and regional industrial context. Across the three countries, course design is increasingly influenced by the growing relevance of battery technologies in the transition to sustainable mobility and energy systems. In **Italy**, training programs at the university level (e.g., LUISS) are defined through a multidisciplinary lens, with course content co-designed by academic staff and informed by emerging policy and industry trends. These courses are often part of Master's programs and target postgraduate students, professionals, and adult learners interested in green transition, innovation management, and sustainability. The training aims to prepare future

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managers, consultants, and policymakers who can operate at the intersection of technology, regulation, and environmental impact. In **Spain**, training courses are more technically oriented, particularly in VET and engineering programs. Course content is increasingly shaped in collaboration with the battery industry and regional authorities. The target audience includes upper-secondary and post-secondary VET students, as well as young engineers entering the workforce. Some courses are also tailored for reskilling or upskilling workers in automotive and energy sectors. In **Hungary**, training programs are still being adapted to match the pace of industrial developments. Universities tend to focus on research and engineering students, while VET schools are beginning to integrate basic battery maintenance and diagnostic content aimed at technicians and entry-level workers in electromobility-related fields. In **Slovakia**, training courses are defined in close coordination with industry under the dual education model. The DSA aligns its curricula with industrial partners' needs, actively involving companies in defining skills and learning outcomes. Target audiences include secondary vocational students enrolled in dual training, as well as apprentices and young graduates participating in workplace learning schemes. Across all countries, a key trend is the shift from purely academic or theoretical content to more applied, skills-based training designed in collaboration with industry stakeholders. The target audiences range from students in technical secondary schools and universities to professionals in need of continuous education.
Describe the training courses: ● How are the training courses defined? ● What teaching tools and methods are used? ● Who is the target audience? ● What are the most common topics?
How are the training courses defined?

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Training courses related to battery technologies are typically defined through a combination of national education frameworks, institutional autonomy, and—most effectively—direct input from industry. In countries with established dual systems (such as Spain and Slovakia), course content is co-developed with private companies and regularly updated to reflect technological changes. In Italy, especially at the university level, courses are structured through interdisciplinary curricula informed by policy, innovation, and sustainability goals. In Hungary, curricula are still evolving and often derive from broader programmes in electrical engineering or automotive technologies.

What teaching tools and methods are used?

Teaching methods vary widely, but there is a general shift toward more applied and interactive approaches. Common tools and methods include:

- **Lectures and seminars** for theoretical foundations (especially in higher education)
- **Hands-on laboratory work** for cell/module assembly, safety, and diagnostics
- **Company internships and apprenticeships**, especially in Spain and Slovakia
- **Digital simulations and SOP-based training**, more common in Hungarian and industrial contexts
- **Case studies and project-based learning**, especially in Italian and Spanish programmes
- **Collaborative modules** with external experts or company mentors

However, VET institutions often face challenges in accessing **modern equipment and up-to-date lab resources**, particularly in Hungary and parts of Italy and Slovakia.

Who is the target audience?

The target audience for battery-related training courses includes:

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- **Upper-secondary VET students** in electromechanics, energy systems, or automotive pathways
- **University students**, mainly in engineering, material science, or innovation management programmes
- **Young professionals and adult learners** in reskilling or upskilling pathways
- **Teachers and trainers**, especially in institutions updating their technical knowledge

While university courses tend to attract learners interested in strategic and R&D aspects, VET courses focus more on operational and production-level competencies.

What are the most common topics?

The most frequently addressed topics across training courses include:

- **Fundamentals of battery operation** and electrochemistry
- **Battery component identification** and functions (cell, module, pack)
- **Safety procedures and high-voltage handling**
- **Basic battery diagnostics and testing**
- **Sustainability, circular economy and end-of-life management**
- **Battery applications in electric vehicles and stationary storage**

Topics such as **advanced BMS, recycling processes, and automated production systems** are less common in standard curricula but increasingly present in pilot initiatives and collaborative projects.

COLLABORATIONS

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Indicate what kind of synergies and collaboration methods are established between the company and training institutions, highlighting critical issues and positive aspects. In addition, indicate which areas of battery technology could benefit from collaboration with companies.
Across Italy, Spain, and Hungary, educational institutions recognize the importance of strengthening partnerships with companies in the battery and electric mobility sectors to ensure that training content remains relevant, up-to-date, and aligned with real-world industrial practices. **Collaboration Methods and Positive Aspects:** ● In **Spain**, there is a well-established tradition of dual training and strong cooperation between VET schools and local companies, particularly in regions like Catalonia and Valencia. Companies often host apprenticeships and co-develop content with training providers, offering direct exposure to battery production environments. This close integration allows students to gain hands-on experience with technologies such as cell assembly, testing equipment, and recycling systems. ● In **Italy**, while formal dual education models are less widespread, collaborations with industry are increasingly project-based. Universities, like LUISS, work with companies through case study development, challenge-based learning, and business labs focused on innovation and sustainability. Although these are less technical in nature, they build strategic, regulatory, and environmental perspectives that are vital for the battery sector. ● In **Hungary**, cooperation is at an earlier stage, but universities have started to create partnerships with large manufacturing firms (e.g., in Debrecen) to ensure that students are exposed to current battery manufacturing practices. Pilot programs and informal collaborations have been launched, particularly in the fields of materials engineering and production systems. ● In **Slovakia**, the DSA offers a more formalised and structured approach. Operating within the national dual education system, DSA collaborates closely with industrial partners in designing curricula, defining learning outcomes, and managing student placements. In collaboration with stakeholders such as InoBat, the academy is directly involved in the development of a national qualification profile for battery technicians. Students benefit from alternating periods of study and practical training, allowing them to acquire both theoretical knowledge and industry-based

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skills. This model represents a concrete example of how VET and industry can co-design effective pathways for emerging technologies.

Critical Issues:

- A common challenge in all three countries is the **fragmentation of collaboration efforts** and the **lack of systematic mechanisms** to sustain long-term partnerships.
- Many institutions still struggle with **limited access to modern industrial equipment**, which prevents them from offering realistic training environments.
- There are **regional disparities**: in less industrialized areas, collaboration opportunities are more limited, and training institutions may lack direct connections with battery-related firms.
- The **bureaucratic complexity** and different paces between academic timelines and industry needs can hinder the development of agile and responsive training modules.

Areas of Battery Technology That Would Benefit Most from Collaboration:

1. **Battery Safety and Risk Management** – requires real-world case studies and updated knowledge of industry protocols.
2. **Battery Assembly and Manufacturing Processes** – collaboration is crucial to access production environments and understand quality standards.
3. **Battery Diagnostics and BMS (Battery Management Systems)** – educational programs often lack up-to-date hardware and data systems that industry can provide.
4. **Recycling and Circular Economy Processes** – collaboration would allow trainees to understand closed-loop systems and innovations in end-of-life battery handling.

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5. **Chemical Components and Materials Science** – partnerships with R&D departments could enhance the scientific depth of training content.

In conclusion, while there are positive examples of cooperation in each country, scaling up and structuring these collaborations—especially in technical and production-related domains—will be essential for building a VET ecosystem capable of supporting the battery sector's rapid evolution.

RESEARCH

ACTIVITIES

Describe the research activities in battery technologies.

Across the countries involved—Italy, Spain, and Hungary—research activities in battery technologies reflect the strategic importance of the sector and its rapid evolution. Institutions and networks interviewed report a strong focus on applied and industrial research, aimed at improving battery performance, safety, and sustainability.

In **Italy**, research activities are closely linked to industrial applications and the development of innovative solutions for the electric mobility sector. Key areas include materials science (e.g., electrode and electrolyte development), battery management systems (BMS), second-life applications, and recycling processes. Italian institutions also explore digital monitoring tools for battery performance and ageing, often in collaboration with industrial partners.

In **Spain**, research is particularly concentrated on battery validation, safety, and the development of new chemistries such as solid-state and sodium-ion batteries. Spanish research institutes also focus on lifecycle analysis (LCA), eco-design, and sustainable production models. Additionally, there is significant emphasis on the certification and standardization of battery systems, which supports industrial scalability and international competitiveness.

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In **Hungary**, research centers and university labs are working to support the growing gigafactory ecosystem. Efforts are directed toward developing efficient manufacturing processes, quality control methods, and production safety. While fundamental research is less prominent, applied research in collaboration with battery manufacturers is increasing, particularly in areas such as cell assembly, automation, and testing.

In **Slovakia**, research is growing in relevance due to the country's strategic focus on battery production. Institutions such as the Technical University of Košice and Pavol Jozef Šafárik University work in close partnership with companies like InoBat to develop next-generation battery chemistries and diagnostic systems. Slovakia has also established the National Battery Centre, which plays a coordinating role across research, training, and industry. Activities include the development of prototypes, cell performance evaluation, and support for pilot production.

Overall, research activities across all three countries aim to align closely with industrial needs, with a shared priority on sustainability, innovation, and workforce readiness for emerging battery technologies.

COLLABORATIONS

Describe how research institutions engage and, at the same time, are engaged in training, dissemination of training courses and curriculum development.

Research institutions in Italy, Spain, and Hungary play a growing dual role—not only advancing innovation in battery technologies but also contributing to education and training efforts that bridge the gap between research, industry, and the VET system.

In **Italy**, universities and specialized research centers are actively involved in designing and delivering training content in collaboration with industry partners. For example, they often co-develop advanced modules for master's programs and postgraduate training, focusing on cutting-edge topics such as battery diagnostics, safety protocols, and circular economy approaches. These institutions also support curriculum development for VET and higher education by integrating real-world research insights and industrial case studies into

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learning pathways. Additionally, researchers frequently participate in public seminars, workshops, and industry-academia initiatives that promote continuous education.

In **Spain**, research institutions are closely linked to vocational and technical training providers, especially through dual education models and sectorial partnerships. Their role in curriculum development is particularly strong in emerging areas such as battery safety, digitalization, and environmental performance. Spanish centers of excellence also contribute to teacher training and host pilot training sessions in partnership with educational bodies, ensuring that training programs remain aligned with the latest technological trends. Dissemination activities often include publishing training materials and contributing to open-access platforms and technical forums.

In **Hungary**, although the formal involvement of research institutions in VET curricula is still limited, their engagement is expanding. Universities and innovation hubs provide guest lectures, specialized training events, and short-term courses targeted at both students and professionals. In some cases, they also collaborate with large battery manufacturers to co-design upskilling and reskilling initiatives. Hungarian research institutions are increasingly being recognized as key players in supporting the alignment of education with evolving industrial demands.

In **Slovakia**, research institutions are proactively integrated into national curriculum development, particularly through the efforts of the National Battery Centre and partnerships between universities (e.g., Technical University of Košice, Pavol Jozef Šafárik University) and industrial actors like InoBat. These institutions contribute to:

- The creation of new national qualification standards (e.g., battery technician profile)
- The development of teaching content based on cutting-edge R&D
- Joint train-the-trainer programmes
- Integration of students into laboratory and pilot production environments, bridging theoretical knowledge and industrial application

Across all three countries, research institutions are progressively assuming a facilitative role in knowledge transfer—transforming scientific progress into practical and accessible

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training content for the education system. Their involvement enhances the quality and relevance of training programs, particularly in fast-evolving sectors like battery technology.
Are there difficulties in transferring knowledge from research into education and, if so, what are they?
Yes, across Italy, Spain, and Hungary, several challenges have been identified in the transfer of knowledge from research into education, particularly within the field of battery technologies. These challenges vary in intensity and form but reveal common structural and systemic issues. In **Italy**, one of the main barriers lies in the **lack of structured and systematic collaboration** between research institutions and VET providers. While universities and research centers often produce cutting-edge findings, these are not always translated into training materials suitable for vocational learners. The **language and complexity of academic research** may not align with the pedagogical needs of VET, and there is a **lack of intermediaries** capable of adapting and simplifying this content for educational use. Furthermore, **limited funding and institutional incentives** to prioritize educational outreach over scientific publication hinder the flow of knowledge into training programs. In **Spain**, despite stronger connections between research and education (especially in dual systems), there are still **issues of timing and coordination**. Often, research results become available **faster than curricula can be revised**, resulting in delays in updating training programs. Additionally, **fragmentation among regional education systems** makes it more difficult to scale successful initiatives nationally. There is also a need for **greater standardization** in the way research findings are incorporated into teaching practices. In **Hungary**, the main difficulties include the **limited tradition of integrating R&D into VET education**, particularly at the secondary level. Research institutions are more aligned with university-level education and have **few established pathways** for collaboration with vocational schools. There is also a **lack of training for VET educators** on how to interpret and apply research outputs in the classroom. Moreover, **intellectual property constraints** or

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commercial sensitivities may restrict the extent to which certain research outcomes can be freely shared or used in educational materials.

In **Slovakia**, the integration between research and education is improving, particularly through initiatives such as the **National Battery Centre** and partnerships with universities and companies like InoBat. However, challenges still exist:

- **Differences in institutional priorities** between research centres (focused on innovation) and VET providers (focused on employability and pedagogy)
- **Lack of didactic translation** of research content: even when research results are available, they are rarely converted into accessible, modular teaching materials
- **Insufficient capacity** in some schools to absorb and apply new content due to outdated infrastructure or limited teacher training
- **Administrative complexity** in coordinating joint actions between multiple stakeholders

Across all three countries, a recurring issue is the **absence of frameworks or dedicated platforms** that facilitate the transfer of knowledge from research to education. Without formalized mechanisms, the collaboration remains dependent on individual initiatives or projects, limiting continuity and scalability. Addressing these gaps will be crucial to ensuring that VET systems can effectively prepare learners for employment in rapidly evolving technological sectors like battery manufacturing and energy storage.

TRAINING PROCESS

Indicate the soft and hard skills that a technician should possess.
Based on the interviews conducted across Italy, Spain, Slovakia and Hungary, a comprehensive set of **hard and soft skills** has emerged as critical for technicians working in

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the battery technology sector. These skills reflect the evolving demands of the industry and the increasing complexity of roles across the battery value chain.

Hard Skills

1. **Battery Chemistry and Electrochemistry Fundamentals**
   Technicians should understand the basic principles of how different types of batteries function, including lithium-ion technology, chemical reactions, and degradation processes.

2. **Battery Management Systems (BMS) Operation**
   Knowledge of how to monitor, test, and interpret data from BMS is essential. This includes familiarity with sensors, diagnostics, and energy efficiency monitoring.

3. **Electrical and Electronic Systems Competence**
   Technicians need skills in measuring voltage, current, and resistance, and working with inverters, converters, and control systems integrated in electric vehicles or energy storage units.

4. **Assembly and Disassembly Procedures**
   Practical knowledge of battery module/cell assembly, as well as safe disassembly for repair or recycling, is a core technical skill.

5. **Safety Protocols and Risk Management**
   Understanding of high-voltage safety procedures, thermal runaway risks, and emergency response actions when working with battery systems.

6. **Recycling and Lifecycle Assessment**
   Familiarity with recycling processes, environmental compliance, and sustainability principles is increasingly valued.

7. **Use of Diagnostic Tools and Simulation Software**
   Competence in using industry-standard tools for testing batteries and performing virtual simulations for design or fault analysis.

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8. **Basic Programming and Digital Literacy**
   As automation grows in battery production and testing, basic coding (e.g., Python, MATLAB) and digital tool usage become advantageous.

Soft Skills

1. **Problem Solving and Critical Thinking**
   Ability to identify faults, analyze technical issues, and propose innovative solutions is key in maintenance, testing, and R&D contexts.
2. **Teamwork and Cross-disciplinary Collaboration**
   The ability to work effectively within multidisciplinary teams including engineers, researchers, and operators is fundamental.
3. **Communication Skills**
   Technicians must be able to clearly document and communicate technical issues, especially in collaborative industrial settings or when interacting with clients.
4. **Adaptability and Willingness to Learn**
   Given the pace of technological change, ongoing learning and openness to retraining are essential traits.
5. **Attention to Detail and Precision**
   Working with high-voltage systems and precision components requires accuracy and consistency in execution.
6. **Project Management and Time Management**
   Skills in organizing tasks, meeting deadlines, and working efficiently in project-based environments are increasingly important, especially in production and prototyping settings.

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These skills are interdependent: technical expertise must be supported by transversal abilities to ensure a technician can function effectively in fast-evolving, collaborative, and safety-critical environments typical of battery manufacturing and maintenance.
What practices, models or suggestions did respondents put forward that could be useful in project activities?
Based on the interviews conducted with research institutions in Italy, Spain, Slovakia and Hungary, several practices, models, and suggestions were highlighted that could effectively support the development of the project's training and knowledge-transfer activities in battery technologies. These insights emphasize not only the content and methods of training, but also the broader collaboration models between research, industry, and education that could be replicated or adapted in the project.

Practices and suggestions highlighted by respondents

1. **Use of Joint Research-Education Infrastructures**
   Respondents pointed to the value of shared lab facilities where students, researchers, and industry professionals can collaborate. For example, some institutions have developed innovation hubs or centers of excellence where hands-on training is combined with applied research activities.

2. **Integration of Real-World Case Studies into Curricula**
   One widely recommended practice is the inclusion of industrial case studies directly drawn from R&D projects. This helps contextualize theoretical learning and introduces learners to real operational challenges and technological solutions.

3. **Hybrid Learning Formats and Modular Training**
   Institutions are experimenting with modular, flexible learning structures that include both online theoretical content and in-person lab work. This format allows for scalability, adaptation to different learner profiles, and alignment with rapidly

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evolving industry needs.

4. **Collaborative Curriculum Design with Industry**
 Respondents stressed the importance of involving industry experts in curriculum development. This ensures alignment with market demands, encourages the use of up-to-date content, and can facilitate smoother transitions from education to employment.

5. **Train-the-Trainer Initiatives**
 Several institutions promote capacity building through trainer-upskilling programs. These initiatives ensure that educators themselves are up to date with the latest battery technology innovations, regulatory changes, and laboratory practices.

6. **Project-Based and Challenge-Based Learning**
 Research partners encourage educational formats where students tackle real battery-sector problems in teams, guided by mentors from academia and industry. This approach fosters critical thinking, teamwork, and application of cross-disciplinary knowledge.

7. **Participation in European Projects and Networks**
 Many institutions actively participate in EU-funded research and training projects, using these platforms to develop open-access materials, e-learning tools, and foster exchange programs. These outputs could be directly reused or adapted within the BATPOWER training framework.

8. **Development of Shared Resource Platforms**
 Respondents suggested creating centralized repositories of teaching content (videos, simulations, lab manuals, datasets) developed in collaboration between universities, companies, and research centers, making knowledge more accessible across institutions.

CONCLUSION

Provides practical examples of elements related to training (content, tools, equipment, models of collaboration with training institutions and/or other organisations or case studies) that were highlighted by interviewees.

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Practical Examples Highlighted by Interviewees

Italy

- **CIRC-eV Lab – Politecnico di Milano:**
  A notable example is the CIRC-eV laboratory, a multifunctional infrastructure where research, training, and innovation activities related to electric vehicle batteries are integrated. The lab includes facilities for disassembly, diagnostics, reassembly, and recycling, and is used both for applied research and student training.

- **Training-Research Synergy:**
  Through European-funded projects, the university collaborates with battery manufacturers to co-develop training modules and technical content, especially on safety, second-life applications, and battery management systems (BMS).

Spain

- **CIDETEC & MUBIL Hub Collaboration:**
  CIDETEC, a key actor in battery research, collaborates with vocational training centers through the MUBIL mobility hub. Students can access real-world battery testing environments and participate in validation processes. This direct exposure to industrial conditions is integrated into formal training programs.

- **Learning by Doing Approach:**
  CIDETEC also supports the development of e-learning tools and virtual labs that replicate industrial battery processes, which are used in blended training programs for VET learners and professionals.

Hungary

- **University-Industry Training Programs:**
  Hungarian universities, such as the University of Debrecen, partner with companies like CATL to jointly design specialized modules on battery chemistry and safety. Students are involved in research projects that feed directly into training activities.

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- **Use of Diagnostic Equipment:**
  Students are given access to real diagnostic equipment used in industry, including tools for BMS analysis, thermal imaging, and electrochemical testing, allowing them to gain hands-on skills in real scenarios.

- **Joint Masterclasses with Industry Experts:**
  Masterclasses and seminars are regularly co-hosted by academic institutions and battery companies, creating platforms for transferring cutting-edge knowledge to both students and teachers.

Slovakia

- The **National Battery Centre** and InoBat collaborate on the development of a **national VET qualification profile for battery technicians**, which includes structured input from research institutions.

- Universities like the **Technical University of Košice** host **pilot battery laboratories** where students can work directly with diagnostic tools, measurement systems, and prototype cells under researcher supervision.

- Research institutions co-develop **train-the-trainer modules** to help VET educators integrate recent scientific knowledge into their classroom practices.

- A **rotation model** is applied where students alternate between academic labs and industrial environments to consolidate both theoretical understanding and technical skills.

Collaborative Models and Tools

- **Case-Based Learning:**
  Institutions use detailed case studies from industry projects (e.g., battery repurposing, safety incident analysis) as teaching material.

- **Shared Innovation Platforms:**
  Some partners have developed digital platforms for sharing teaching content,

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experimental data, and simulation tools across institutions and countries.

- **Dual Engagement of Experts:**
  Researchers and engineers often serve dual roles as trainers and mentors, bridging the gap between theoretical content and its application in real-world settings.

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