Project Nr.: 2024-1-SK01-KA220-VET-000256192

BATPOWER
Preparation of the VET sector on battery energy transition

BatPower: Preparation of the VET sector on battery energy transition

2024-1-SK01-KA220-VET-000256192

WP2/A2.1.

Identification of specific gaps and needs in battery energy education

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Annexes:

- Desk Research on gaps and needs in energy education, Spain
- Desk Research on gaps and needs in energy education, Hungary
- Desk Research on gaps and needs in energy education, Italy
- Desk Research on gaps and needs in energy education, Slovakia

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Introduction and Methodology

The rapid expansion of the battery sector, driven by the accelerating energy transition and the evolution of the automotive industry, is reshaping the skills landscape across Europe. As the demand for new technologies and production systems grows, educational and training systems are called to respond with increasingly specialized and flexible learning pathways.

This report presents a cross-country analysis of the desk research conducted by project partners in Italy, Spain, Slovakia, and Hungary. Its aim is to identify common trends, regional challenges, specific needs, and strategic recommendations concerning the alignment between vocational education and training (VET) systems and the evolving requirements of the battery sector.

The methodology adopted focused on four main areas of investigation: the identification of key educational gaps, the regional distribution of challenges, the definition of specific needs for students, educators, and industry, and the collection of coherent recommendations for interventions. Each section of the report is structured to highlight common patterns, notable differences among national contexts, and areas of priority for future development.

By synthesizing evidence across different countries, this analysis offers a consolidated view of how VET systems can adapt to better support the skills needs arising from the battery and energy transition, with a particular emphasis on building stronger links between education, innovation, and industrial practice.

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1. Key Educational Gaps

The cross-country analysis of the national contexts highlights the existence of significant gaps in vocational education and training (VET) related to battery technologies. Despite differences in educational and industrial systems among the countries examined (Italy, Spain, Slovakia, Hungary), several common areas of weakness emerge, grouped into three main categories: **technical knowledge**, **practical skills**, and **soft skills**.

1.1 Technical Knowledge

All countries analyzed report a lack of specialized education covering the technical foundations essential for working in the battery value chain. In particular, advanced knowledge of battery chemistry, which is crucial for understanding energy storage processes, is either treated superficially or absent from curricula. Italian and Spanish sources emphasize the need to introduce specific modules on advanced chemistry and different cell technologies, while Hungary highlights a lack of training in electrochemical processes and the operating principles of various battery types. Similarly, Slovakia reports the absence of specialized curricula addressing these topics.

Life cycle management, recycling processes, and sustainability are additional areas poorly integrated into educational programs, despite being recognized as strategic for supporting the energy transition. Likewise, topics related to operational safety, emergency protocols, and risk management are often neglected or treated unsystematically.

Further critical issues arise in the fields of battery diagnostics, Battery Management Systems (BMS), and performance monitoring. Hungary, in particular, points out the lack of training in BMS usage and concepts such as cell balancing, while both Italy and Hungary report difficulties faced by

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educational institutions in keeping pace with the rapidly evolving industrial standards.

1.2 Practical Skills

Limited hands-on experience emerges as a structural weakness across all countries analyzed. Italian and Spanish sources highlight the lack of laboratories equipped with modern technologies, while Hungary notes the absence of adequate laboratory infrastructure, electric/hybrid vehicles, and updated diagnostic tools. In Slovakia, access to battery testing laboratories is often restricted to private companies, making it difficult for students to gain direct practical experience.

Internship and apprenticeship opportunities are also reported as insufficient or inadequately structured. Hungary and Spain point out that existing dual training systems do not guarantee meaningful industrial experience, due to insufficient collaboration between educational institutions and companies.

1.3 Soft Skills

Soft skills, which are increasingly crucial in a technologically advanced and interdisciplinary sector like batteries, remain underdeveloped in VET pathways. Skills such as teamwork, project management, interdisciplinary collaboration, adaptability to green technologies, and digital literacy are only partially integrated into training programs.

Spanish sources highlight strong variability in the integration of soft skills, depending on the program and institution. In Italy, the lack of emphasis on soft skills is considered a major weakness of the VET system. Hungary provides a detailed overview of soft skill gaps, particularly concerning project management and digital competencies specific to the battery sector. Slovakia reports specific difficulties in cross-functional collaboration and project management within industrial settings.

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HIGHLIGHTS

The main educational gaps identified relate to:

- the need to update VET curricula with advanced and relevant technical content, particularly regarding battery chemistry, safety, life cycle management, and advanced diagnostics;
- the strengthening of practical training through better access to modern laboratory facilities and stronger cooperation with industry;
- the enhancement of soft skills development, deemed essential for operating effectively within a complex and rapidly evolving industrial environment.

These findings underline the urgency of a coordinated rethinking of vocational education systems, aimed at supporting a competitive and sustainable energy transition.

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2. Regional Challenges

The analysis of national sources highlights that educational challenges related to the battery sector are not uniformly distributed within countries. Instead, they often reflect the geographical concentration of industrial activities and the availability of existing infrastructures.

2.1 Spain

In Spain, clear regional disparities are reported. Regions such as Catalonia are leading reindustrialization efforts and battery manufacturing activities, thus requiring a larger pool of specialized technicians. Conversely, areas such as Asturias face regulatory barriers that hinder the development of battery parks and related industrial activities. These regional differences significantly influence the speed and approach adopted in addressing educational and training challenges across the country.

2.2 Italy

Italy also presents marked regional disparities. Northern regions (Piedmont, Lombardy, Veneto, and Emilia-Romagna) benefit from a consolidated industrial base, a dense network of technical universities, and greater access to internships, apprenticeships, and laboratory facilities. Although Central and Southern regions are becoming increasingly involved, they offer different levels of opportunity and readiness. National sources suggest adopting a territorial approach: in the North, efforts should focus on systematizing collaborations, while in the Center and South, priorities should include the creation of new infrastructures and stronger partnerships between education providers and industry.

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2.3 Hungary

In Hungary, the integration of battery-related education is uneven across educational levels and institutions. Existing vocational education and training (VET) programs focus more on electric vehicle maintenance rather than on battery production, diagnostics, and recycling. While higher education institutions tend to prioritize research and development (R&D), there remains a notable gap between academic output and industrial expectations, particularly regarding practical knowledge. Regional challenges also include limitations in the dual training system and the insufficient collaboration between educational institutions and the industrial sector.

2.4 Slovakia

Slovakia has made progress in recent years, partly driven by initiatives such as InoBat. However, historically, the country lacked comprehensive educational programs in the fields of electromobility and battery business development. Regional disparities are still evident in training opportunities. Furthermore, the Slovak battery industry is reportedly hindered by a scarcity of startups and innovative initiatives, suggesting potential gaps in entrepreneurial education and innovation skills development at the regional level.

Highlights

- **Regional disparities are significant across all countries** and impact the availability and quality of VET opportunities related to battery technologies.
- **Spain**: Strong regional differences; Catalonia is a leader in battery industry development, while other regions (e.g., Asturias) face regulatory barriers limiting growth.

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- **Italy**: Industrial concentration and better educational infrastructures in Northern regions contrast with slower development in Central and Southern regions; a differentiated, territorial approach is recommended.
- **Hungary**: Uneven integration of battery education across regions; vocational training remains focused on vehicle maintenance rather than broader battery technologies; dual education systems need reinforcement.
- **Slovakia**: Regional inequalities persist; lack of comprehensive battery education programs historically; limited presence of startups and innovative initiatives highlights gaps in entrepreneurial education.
- **Common Issue**: Collaboration between educational institutions and local industries needs strengthening to ensure regionally balanced skills development and industrial support.

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3. Identification of Needs

The identification of the main educational gaps across the partner countries has led to a more detailed understanding of the specific needs expressed by the three main stakeholder groups involved in the battery and energy transition: students, educators, and industry. Although the national contexts present some differences, the analysis highlights several common trends and interdependencies.

3.1 Students' Needs

Students across all countries underline the importance of having access to updated and practical learning environments. This includes not only the availability of well-equipped physical laboratories but also the integration of digital laboratories, simulators, and real-world case studies capable of replicating the complexity of industrial battery processes.

The need for structured, high-quality internship programs is strongly emphasized. Students seek more opportunities for direct exposure to industrial environments, allowing them to bridge the gap between theoretical learning and practical application. In Italy, in particular, students stress the importance of structured and paid internships as a critical factor for enhancing employability. Meanwhile, in Hungary, students highlight the need for better knowledge transfer mechanisms from research institutions to industrial practice, as well as a reduction in regulatory and administrative barriers that currently limit access to hands-on training.

In Slovakia, the demand is primarily focused on improving the availability of modern tools and equipment that enable students to directly interact with advanced battery systems, thus fostering a deeper understanding of production, management, and recycling processes.

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Overall, students are seeking a learning experience that is more closely aligned with market realities, combining solid technical knowledge with the ability to operate within dynamic, technology-driven industrial contexts.

3.2 Educators' Needs

Educators also face specific challenges in adapting their teaching to the fast-changing landscape of battery technologies. A recurring theme across all countries is the need for continuous professional development and access to updated technical knowledge, particularly in emerging areas such as battery safety, life cycle management, diagnostics, and recycling technologies.

The effective delivery of education in these fields depends heavily on the availability of modern teaching resources, including well-equipped laboratories, industrial simulation environments, and curriculum materials developed in collaboration with industrial players.

Beyond resources, educators express the need for institutional support that enables them to participate in research and innovation projects, strengthening their capacity to bring cutting-edge knowledge into the classroom. Involvement in collaborative networks that include companies and research centers is seen as essential for maintaining the relevance of educational programs and fostering a dynamic exchange between theory and practice.

3.3 Industry's Needs

From the industry's perspective, the primary need is for qualified professionals who possess both theoretical knowledge and practical skills in the fields of battery assembly, testing, management, and diagnostics. The industry expects

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graduates to be immediately operational within production and maintenance environments, minimizing the need for extensive on-the-job training.

Given the pace of technological change, there is also a growing demand for flexible, short-term training solutions, aimed at providing upskilling and reskilling pathways for the existing workforce. These pathways should help current employees adapt to new technologies and production standards in the battery sector.

Moreover, industry stakeholders stress the importance of deepening partnerships with educational institutions, not only through internship programs but also by participating in curriculum design, joint research initiatives, and resource sharing (such as access to equipment and laboratories). A stronger industry-education collaboration is perceived as crucial to ensure that training systems produce graduates with the competencies actually required by evolving industrial environments.

Highlights

- **Students**:
    - Need access to modern physical and digital laboratories, simulations, and real-world case studies.
    - Require structured, paid internships and closer ties to industrial practice.
    - Demand better alignment between theoretical curricula and practical market-oriented competencies.
- **Educators**:

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- Require continuous professional development and training on emerging battery technologies.
- Need updated teaching materials, access to modern laboratories, and resources co-developed with industry.
- Call for stronger involvement in research projects and industrial innovation networks

- **Industry**:
  - Requires skilled professionals ready for immediate roles in battery production, diagnostics, and management.
  - Needs flexible upskilling and reskilling programs to adapt the existing workforce to new technological demands.
  - Seeks more systematic collaboration with education providers for curriculum co-design and shared training resources.

Cross-cutting Insight:

The needs expressed by students, educators, and industry are highly **interdependent**. Students require more practical, industry-relevant education; educators can only deliver this if they themselves have up-to-date knowledge and access to appropriate infrastructure; and industry, in turn, must play an active role in shaping educational content and providing real-world learning opportunities. Without a systematic and structured collaboration among these three groups, efforts to strengthen VET systems and support the battery and energy transition risk being fragmented and insufficient.

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4. Recommendations for Interventions

The analysis of national sources leads to a coherent set of recommendations aimed at addressing the identified educational gaps and preparing a workforce capable of supporting the battery and energy transition. These recommendations consistently focus on three main pillars: development of teaching materials, training programs, and collaboration with industry.

4.1 Development of Teaching Materials

One of the fundamental recommendations is the development of structured and modular curricula covering key topics essential to the battery sector. These topics include basic and advanced battery chemistry, life cycle management, recycling processes, safety protocols, and battery diagnostics.

The integration of practical and interactive resources into the educational offer is strongly encouraged. This includes the use of practical manuals, digital learning tools, industrial simulations, and virtual laboratories to enhance students' technical skills and practical understanding.

Moreover, the direct involvement of industry in the development of curricula and educational materials is considered crucial to ensure alignment with current market needs and technological trends. Establishing mechanisms for systematic collaboration with companies in curriculum design processes would help guarantee that training pathways remain relevant and responsive to the sector's rapid evolution.

4.2 Training Programs

The need for train-the-trainer programs is emphasized across countries as a strategic measure to continuously update educators on the latest technological developments, safety regulations, and industrial best practices.

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These programs would ensure that teachers and trainers are fully equipped to deliver cutting-edge content to students.

Short-term certification courses and stackable modules are also recommended for both students and professionals, focusing on specialized competencies such as battery production, testing, safety procedures, maintenance, and recycling.

In addition, the adoption of flexible learning modalities, including online and hybrid courses, is suggested to expand access to training opportunities, particularly for adult learners and working professionals who require adaptable pathways for reskilling and upskilling.

4.3 Collaboration with Industry

Strengthening strategic and systematic partnerships between educational institutions and companies is a recurring recommendation across all national contexts. Effective collaboration mechanisms should include the provision of structured internships, apprenticeships, and practical placements that offer direct exposure to industrial environments.

Embedding real industrial case studies and challenges into curricula is identified as an effective method to enhance students' problem-solving skills and deepen their understanding of real-world sectoral dynamics.

Furthermore, access to industrial equipment and the involvement of sector experts in teaching activities—whether through guest lectures, project mentorship, or technical workshops—are seen as important ways to bridge the gap between education and industrial practice.

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Highlights

- **Teaching Materials**:
  - Develop modular curricula covering key topics: battery chemistry, life cycle, recycling, safety, and diagnostics.
  - Integrate practical resources: manuals, simulations, digital tools, virtual laboratories.
  - Ensure active industry involvement in curriculum and materials development.
- **Training Programs**:
  - Implement train-the-trainer programs to continuously update educators.
  - Create short-term certification courses and stackable modules focused on specialized skills.
  - Promote flexible learning modalities (online and hybrid) for wider accessibility.
- **Collaboration with Industry**:
  - Strengthen partnerships for structured internships, apprenticeships, and real-world training experiences.
  - Integrate industrial case studies and challenges into educational curricula.
  - Facilitate access to industrial equipment and the participation of sector experts in educational activities.

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The recommendations outlined above are widely aligned across the countries analyzed, reflecting the common nature of the gaps identified. The priority emerging from this cross-country analysis is to create a more agile, practice-oriented, and industry-connected education ecosystem, capable of supporting the fast-evolving needs of the battery sector and contributing effectively to the broader objectives of the energy transition and industrial competitiveness.

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WP2/A2.1: Desk research on gaps and needs for the battery energy education within the secondary VET level in Spain

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1. Executive summary

The **BATPOWER** project analyses the gaps and needs in Vocational Education and Training (VET) in battery energy in Spain, aiming to align education with the sector's requirements. The energy transition and the increasing demand for sustainable batteries make it essential to have a skilled workforce to address challenges in production, recycling, and energy management.

Currently, three main gaps in VET have been identified:

- Shortage of qualified personnel, with demand exceeding supply in chemistry, electrical engineering, and advanced technologies.
- Mismatch between training and industrial needs, as programs do not evolve at the pace of the sector.
- Deficiencies in infrastructure and educational equipment, limiting practical learning.

To bridge these gaps, key interventions are proposed:

- Development of educational materials with modules on advanced chemistry, recycling, and safety protocols.
- Training programs for teachers and students, including specialized courses and battery certifications.
- Collaboration with the industry, establishing partnerships with companies like SGS TECNOS to provide internships, certifications, and case studies in curricula.

Additionally, the report highlights regional challenges, with regions like Catalonia driving battery reindustrialization, while others, such as Asturias, face regulatory barriers limiting their development.

In conclusion, to position Spain as a leader in sustainable batteries, it is crucial to modernize VET, integrate industry-based training, and promote continuous education. This will ensure a skilled workforce, boosting the country's competitiveness in the energy transition and electric mobility sectors.

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2. Introduction

The European Green Deal, launched in 2019, aims to make the European Union the first climate-neutral continent by 2050. To achieve this, it promotes a sustainable and circular economy, protecting natural resources and ensuring citizens' well-being. One of its key pillars is the energy transition, which involves replacing fossil fuels with renewable energy sources, reducing emissions, and fostering sustainable production and consumption models.

In this context, sustainable batteries play a crucial role in meeting the Green Deal's objectives. Their development is essential for electric mobility and the integration of renewable energies. European regulations require batteries to be sustainable, safe, and high performing throughout their life cycle, encouraging recycling and material reuse.

However, for Europe to lead this transition, a highly skilled workforce in battery manufacturing, management, and recycling is essential. In Spain, Vocational Education and Training (VET) and higher education are adapting to the sector's needs, but significant challenges remain. Currently, three main gaps in talent training for the battery sector have been identified:

1. Shortage of qualified personnel, with demand for specialists in chemistry, electrical engineering, and emerging technologies exceeding the current supply.
2. Mismatch between education and industry needs, causing training programs to lag sector advancements.
3. Deficiencies in infrastructure and educational equipment, limiting hands-on learning and access to modern tools.

To bridge these gaps, the following strategies must be implemented:

- Development of specialized programs in collaboration with the industry, aligning training with the skills required in the battery sector.
- Strengthening of Dual VET, combining theory and practical experience in real-world settings.
- Investment in educational infrastructure, equipping laboratories with advanced technology.

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- Continuous skills updates, ensuring that active professionals adapt to innovation.
- Enhanced collaboration between industry and academia, facilitating knowledge transfer and curriculum adaptation.

Implementing these actions will help build a highly skilled workforce, boosting the battery industry's growth and making a significant contribution to the energy transition promoted by the European Green Deal. The sector's sustainability and competitiveness will largely depend on the ability to train and adapt professionals who will drive this transformation.

3. Methodology

To conduct this study on battery technology training in Spain, a methodology was applied based on data collection from multiple sources and an analysis of existing training gaps in the sector.

Data Sources

The study relies on various sources to examine battery technology training in Spain:

- Institutional sources: European Union, Ministry of Education, Vocational Training and Sports, and Ministry of Industry and Tourism.
- Battery training programs: ITE, 3iEnergia, and ANGEREA initiatives focused on energy storage, transportation, and battery recycling.
- Industry collaboration: Studies from SGS TECNOS, Fundación Primero de Mayo, and Espacio Bertelsmann, assessing labour profiles and the connection between education and employment.
- Research and education: Educational tools from the University of Vigo for lithium battery teaching and studies on physics simulations and teacher training.
- Funding: Spanish Government.

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Focus Areas

The analysis concentrated on the following key aspects:

- Technical knowledge: Assessment of training in electricity, electronics, physics, physical chemistry, chemistry, and related disciplines.
- Practical skills: Identification of gaps in access to laboratories and digital tools for applied learning.
- Soft skills: Evaluation of project management, teamwork, and adaptation to sustainable technologies.
- Educational gaps in Spain: Comparison of training supply with labour market demands, emphasizing industry collaboration and the need for continuous training.

This methodology provides a comprehensive view of the current state of battery training in Spain, serving as a foundation for developing strategic recommendations to enhance the connection between education and industry needs.

4. Review of Current Programs and Gaps

4.1 Technical Training

When discussing gaps between education and industry needs, we refer to mismatches between the training students receive and the skills required in the job market. These gaps can hinder graduates' employability and limit business competitiveness by making it difficult for companies to find professionals with the right profile.

To analyse the training offer in the battery sector, we will first review public programs. Our focus is on the Vocational Education and Training (VET) catalogue, highlighting qualifications that cover key areas related to batteries and their industrial applications.

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Before examining specific programs, it is essential to understand how VET is structured in Spain. This system is divided into different levels, each designed to address different degrees of specialization and market needs, allowing both academic and professional progression.

Vocational Education and Training is part of the National Education System, aimed at preparing students for specific professional roles. Depending on the complexity of the training, it is divided into three levels:

- Level 1 – Basic VET
- Level 2 – Intermediate VET
- Level 3 – Advanced VET

In rapidly evolving sectors such as batteries and the energy transition, specialization is key. Therefore, in addition to standard VET programs, specialization courses are available to complement existing VET qualifications. These programs enable professionals to update and specialize in emerging technologies, improving their integration into high-demand industries, such as sustainable batteries.

Below is a table outlining the VET programs available in Spain that include relevant content for the battery industry. This table highlights subjects related to the sector, providing a clear overview of applicable training areas.

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Level	Field	Titles	Subjects
Basic Vocational Training	**Electricity and Electronics**	Basic Professional Degree in Electricity and Electronics	*Electrical and home automation installations* *Electrical and electronic equipment*
		Basic Professional Degree in Metal Element Manufacturing	*Electrical and electronic equipment*
		Basic Professional Degree in Electrotechnical Installations and Mechanics	*Electrical and home automation installations*
	Transport and Vehicle Maintenance	Basic Professional Degree in Vehicle Maintenance	*Vehicle electricity*
Intermediate Vocational Training	**Electricity and Electrotechnics**	Technician in Electrical and Automated Installations	*Electronics* *Electrotechnics* *Photovoltaic solar installations*
	Installation and Maintenance	Technician in Electromechanical Maintenance	*Electrical-electronic assembly and maintenance*
	Transport and Vehicle Maintenance	Technician in Vehicle Electromechanics	*Auxiliary electrical circuits in vehicles*
	Chemistry	Technician in Chemical Plant	*Operations of energy generation and transfer in chemical processes* *Principles of electromechanical maintenance*
Higher Vocational Training	**Electricity and Electronics**	Senior Technician in Industrial Automation and Robotics	*Electrical, pneumatic, and hydraulic systems* *Advanced programmable systems* *Industrial robotics* *Industrial communications* *Integration of industrial automation systems* *Intermodular project on automation and industrial robotics*
		Senior Technician in Electronic Maintenance	*Maintenance of industrial electronic equipment* *Techniques and processes for assembling and maintaining electronic equipment*
		Senior Technician in Electrotechnical and Automated Systems	*Techniques and processes in electrical installations* *Electrical systems and circuits* *Configuration of electrical installations* *Management of installation assembly and maintenance*
	Installation and Maintenance	Senior Technician in Industrial Mechatronics	*Electrical and electronic systems*
	Transport and Maintenance	Senior Technician in Automotive Technology	*Electrical safety and comfort systems*
	Chemistry	Senior Technician in Laboratory Analysis and Quality Control	*Physical tests* *Physicochemical tests*
		Senior Technician in Industrial Chemistry	*Energy generation and recovery* *Electromechanical maintenance in process industries*
Specialization Courses	**Electricity and Electronics**	Specialization Course in Collaborative Robotics (Higher Level Entry)	*Collaborative Robotics* *Configuration and programming* *Autonomous Mobile Robots*

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	Transport and Vehicle Maintenance	Specialization Course in Hybrid and Electric Vehicle Maintenance (Intermediate Level Entry)	*Safety in hybrid and electric vehicles* *Propulsion systems in hybrid and electric vehicles* *High-voltage electrical systems, batteries, and charging* *Force transmission and thermal management*
		Specialization Course in Maintenance and Safety in Hybrid and Electric Vehicle Systems (Higher Level Entry)	*Safety in high-voltage vehicle systems* *Electric and hybrid vehicle traction* *High-voltage systems, storage, and electric charging* *Transmission systems, regenerative braking, and thermal control*

The table presented demonstrates that Vocational Training (FP) in Spain has significantly evolved in recent years, incorporating subjects and programs aligned with the technological and energy revolution. Some key highlights include:

- ✓ Integration of renewable energies and electric mobility.
- ✓ Promotion of automation and robotics.
- ✓ Presence of applied chemistry in industrial processes.
- ✓ Specialization courses in electric and hybrid vehicles.

Despite these notable advances, there are still areas for improvement:

- Lack of training in advanced battery chemistry.
- Limited education on stationary energy storage.
- Weak offering in energy management and charging infrastructure.
- Lack of training in battery recycling, energy storage, and smart grids.

While public Vocational Training in Spain has gradually incorporated modules on batteries and energy storage, it still lacks advanced specialization. In response, the private sector has developed specific courses and programs that address these gaps, offering up-to-date training in emerging technologies, certification, and industrial applications.

These courses enable professionals to acquire key skills for the energy transition, adapting to the real needs of the market. The most relevant ones are presented below:

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Specialist Course in Energy Storage (Instituto Tecnológico de la Energía, ITE)

This program provides a comprehensive overview of storage technologies, with a focus on batteries. It covers topics such as the evolution of the battery market, key parameters, characterization techniques, environmental sustainability, and energy storage system management. [3]

Ibero-American Institute of Energy Engineers (3iE Energía)

3iE Energía is an institution dedicated to specialized training in the energy sector. It offers a wide range of courses covering various areas such as renewable energies, energy efficiency, electric mobility, hydrogen, and industrial safety. [4] Some of the courses offered include:

- Electric Vehicle Charging Systems
- Electric Vehicles
- Energy Storage

Course on Storage and Transport of Lithium Battery Waste for Automotive Applications (ANGEREA)

This course aims to enhance and update knowledge of current legislation regarding the management, transport, and storage of used lithium batteries in the automotive sector. [5]

4.2 Training in Practical Skills

In Spain's Vocational Education and Training system, a gap has been identified in testing and the use of modern tools, particularly in battery technologies. This is due to the sector's rapid evolution and the ongoing need to update training programs to align with market demands. Although VET has prioritized practical learning, the integration of advanced simulations and specialized laboratories remains limited, partly due to a lack of resources and appropriate infrastructure.

To address this gap, the Ministry of Education, Vocational Training, and Sports is developing new qualifications, including a Higher Technician degree in

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energy storage operations and professional certificates for continuous training in this field. However, the incorporation of testing and simulation laboratories is still in its early stages, making it challenging for students to be fully prepared for the job market.

Regarding workplace internships, Basic VET requires a minimum of **240 hours**, while **Intermediate and Advanced VET cycles require 400 hours**, usually between March and June of the second academic year [6]. The **Dual VET system** combines training at educational centers with practical experience in companies, increasing the number of hours spent in real work environments [7].

In summary, while significant steps are being taken to improve practical training in battery technologies within Spain's VET system, challenges persist in integrating modern tools and testing environments. Addressing these shortcomings is crucial to preparing professionals who will lead the country's energy transition and technological innovation.

4.3 Training in soft skills

In Spain's Vocational Education and Training (VET) system, the integration of soft skills, such as project management, teamwork, and adaptation to green technologies, varies depending on the program and educational institution. Traditionally, VET has prioritized technical competencies, but in recent years, the importance of complementing technical training with these transversal skills has been recognized as essential for improving employability.

To address this need, the Professional Module on Business and Entrepreneurial Initiative (EIE) has been implemented in Intermediate and Higher VET cycles, fostering self-employment, innovation, and business management [8]. Additionally, initiatives like the Coca-Cola GIRA Jóvenes program have strengthened teamwork, communication, and critical thinking among VET students [9].

Despite these advances, the integration of soft skills in VET curricula is not uniform. Some programs may not explicitly cover competencies such as project management or adaptation to green technologies. This variability may

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be due to a lack of resources, specific teacher training, or the absence of clear guidelines in study plans.

To bridge these gaps, it is essential for educational institutions to integrate specific modules that promote the development of soft skills. Additionally, collaboration with companies and organizations can provide students with practical experiences where they can apply and reinforce these competencies in real-world settings.

In summary, while efforts have been made to incorporate soft skills into Spain's VET system, there is still room for improvement. Strengthening training in project management, teamwork, and adaptation to green technologies is crucial to preparing students for the challenges of today's labour market.

4.4 Regional Challenges

In Spain, the need for training in battery technologies presents common challenges across the country, such as updating educational curricula and integrating specialized competencies in this field. However, significant regional differences exist in the development and implementation of these technologies.

Catalonia is actively investing in electric vehicle battery production, with projects in Mont-roig del Camp and Sallent. This expansion requires a larger workforce of specialized technicians, but a lack of adequate training could create a gap between supply and demand, potentially slowing the sector's growth [10].

In contrast, Asturias faces regulatory obstacles in the installation of battery parks, as regulations restrict their placement to industrial land. This limitation has led to the cancellation of numerous projects, creating uncertainty regarding the future viability of energy storage investments in the region [11].

Additionally, the permitting process remains a nationwide challenge, as the lack of experience in handling battery project approvals complicates investment efforts and delays the creation of specialized jobs [12].

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These regional differences highlight that, while training challenges in battery technologies are broadly shared across Spain, local factors influence both the speed and approach in addressing them.

5. Identification of Requirements

5.1 Student Needs

In Spain's battery technology sector, students face significant challenges that require practical and up-to-date training. Addressing these needs involves providing access to modern learning tools and fostering closer collaboration with industry.

The integration of digital technologies in education is essential to enhance the teaching-learning process. Tools such as simulations, interactive case studies, and digital laboratories allow students to experience real-world scenarios in controlled environments, deepening their understanding of complex concepts. For example, a study published on *arXiv* analyzing the use of simulations in modern physics education found a substantial increase in student comprehension [13].

In Spain, collaboration between educational institutions and industry is becoming increasingly common, but there is still room for improvement. Establishing strategic alliances between training centers and companies is crucial to align students' education with labor market demands. These partnerships enable the development of internship programs, joint projects, and mentorship opportunities, giving students direct insight into the practical applications of their studies.

Such initiatives not only enrich academic training but also facilitate graduates' entry into the workforce. According to a study published by Espacio *Bertelsmann*, schools using the Xcelence framework for career guidance saw a 20% improvement in collaboration between educational institutions and businesses [14].

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Despite recent progress, Spain still lags behind other countries in terms of educational-industry collaboration. Expanding and strengthening these partnerships is crucial to ensuring that student training aligns with labor market needs and to driving economic development and innovation.

5.2 Educators' Needs

In the field of teaching energy storage batteries in Spain, educators face challenges related to training, continuous updating, and the availability of adequate teaching resources. The rapid evolution of energy storage technologies requires teachers to stay constantly up to date.

A study indicates that Spain faces a shortage of resources and educational materials, ranking below international averages in educational investment [15]. This lack of investment can result in a scarcity of modern tools, such as digital laboratories and simulations, which are essential for effectively teaching advanced technologies like energy storage batteries.

Educators primarily demand:

- **Continuous training programs:** More opportunities to update their knowledge on emerging topics such as battery safety, lifecycle, and recycling.
- **Access to modern resources**: Availability of updated teaching tools that facilitate practical and effective learning.
- **Institutional support:** Greater backing from educational institutions and government agencies to implement new methodologies and resources in the classroom.

These demands highlight the need for greater investment in teacher training and the provision of adequate resources to ensure high-quality education in the field of energy storage batteries in Spain.

5.3 Industry Needs

In Spain, the energy storage and electric mobility industry is experiencing significant growth. This boom is reflected in major projects, such as the upcoming construction of a battery gigafactory by Stellantis and CATL in

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Figueruelas, Zaragoza, which will create new investment and employment opportunities in the sector.

This expansion of projects has increased the demand for professionals with specific skills in battery assembly, testing, and system management. A report from CCOO highlights the importance of acquiring these skills through training to boost sector development [16].

To meet this demand, specialized training programs have been implemented. In 2022, the Ministry of Industry, Commerce, and Tourism, in collaboration with the Servicio Extremeño de Empleo (SEXPE), launched the first energy storage battery training program [17].

Additionally, the Spanish government has approved the allocation of €867.28 million for vocational training programs to enhance workforce skills in emerging sectors, including battery technology [18].

In conclusion, implementing specialized training programs and investing in workforce upskilling are essential to meet industry demands and ensure Spain's leadership in the sector.

6. Recommendations for Interventions

6.1 Development of Educational Materials

In Spain, the growing importance of energy storage batteries in sectors such as electric mobility and renewable energy requires the development of specialized educational materials for Vocational Training. These resources should cover everything from battery fundamentals to advanced topics such as chemistry, recycling, and safety.

It is essential to design educational modules that address:

- **Battery fundamentals:** Types, operation, and applications.
- **Advanced chemistry:** Electrochemical reactions and innovative materials.

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- **Recycling:** Battery management and reuse techniques.
- **Safety:** Regulations and best practices for safe handling.

An example of an initiative in this field is the educational tool developed by the **University of Vigo**, which focuses on the operation and safety of lithium-ion batteries [19]. Additionally, the inclusion of **practical manuals and digital tools** enhances active learning. **Interactive Tools for Collaborative Learning (HIPAC)** encourage student participation, while platforms like **VET Conecta**, launched by the **Ministry of Education**, foster interaction between students, teachers, and companies [20].

In conclusion, to improve training in energy storage batteries, it is essential to develop educational materials that integrate theory, practice, and interactive digital tools, ensuring comprehensive preparation aligned with industry demands.

6.2 Training Programs

To design effective train-the-trainer programs in the field of energy storage batteries in Spain, it is essential to base them on studies and best practices that have proven successful in teacher training. Below are some recommendations based on research and previous experiences:

1. Identify the competencies and knowledge that trainers need to acquire or reinforce.
2. Develop educational materials that reflect the latest advancements in battery technology.
3. Implement participatory methodologies to engage trainers. Techniques such as case studies, group discussions, and hands-on simulations facilitate deeper understanding and the practical application of knowledge.
4. Integrate digital platforms and interactive resources into training programs to enrich the teaching process and facilitate access to up-to-date information.
5. Establish periodic evaluation mechanisms to monitor trainers' progress and adjust the program as needed.

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By incorporating these research-backed practices and past experiences, it is possible to develop more effective train-the-trainer programs aligned with the current needs of the energy storage battery sector in Spain.

6.3 Collaboration with Industry: The Role of SGS

Integrating industry placements and real-world case studies into vocational training ensures that graduates enter the workforce with applicable experience rather than just theoretical knowledge. Learning in real environments allows students to:

- Gain hands-on experience in battery testing and validation, which is difficult to replicate in traditional educational settings.
- Understand the regulations and safety standards governing battery manufacturing and certification.
- Develop problem-solving skills by tackling real-world challenges faced in the sector.

SGS, a global leader in inspection, testing, and certification, has a strong presence in Spain, with specialized laboratories and training programs in battery safety and quality. Establishing partnerships with SGS TECNOS could enable:

- Professional internships in specialized laboratories: Students would have the opportunity to familiarize themselves with battery certification and testing processes, gaining hands-on experience with safety regulations, quality control, and performance assessment.
- Integration of real-world case studies into educational programs: Collaboration with SGS would allow educational institutions to access real-life battery testing scenarios, failure analysis, and compliance criteria, enhancing the practical focus of learning.
- Certification of competencies in battery safety and testing: SGS TECNOS could offer official certifications validating students' skills in safety assessment, regulatory compliance, and battery testing procedures.
- Development of continuing education programs for professionals: Beyond initial training, SGS TECNOS could collaborate in upskilling

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industry professionals through specialized courses on new standards, emerging technologies, and advanced battery testing techniques.

In summary, this collaboration would help bridge the gap between education and industry, ensuring that graduates from Vocational Training and higher education programs are well-prepared to tackle the challenges of the battery sector in Spain.

7. Conclusion

This study has identified the main gaps in battery training in Spain, focusing on three key areas: technical knowledge, practical skills, and transversal competencies. The shortage of qualified personnel, the disconnect between educational programs and industry needs, and the lack of adequate infrastructure remain significant barriers to developing a specialized workforce.

To address these challenges, strategic recommendations have been proposed, focusing on:

- Enhancing curricula by incorporating modules on advanced chemistry, battery recycling, and safety protocols.
- Continuous training for educators, ensuring that teachers have up-to-date tools and knowledge.
- Stronger collaboration with the industry, establishing partnerships with companies to facilitate internships, certifications, and real-world case studies in educational programs.

As next steps, it is essential to implement the proposed interventions, ensuring that vocational training keeps pace with industry advancements. This will allow Spain to develop a highly skilled workforce, ready to face the challenges of the energy transition, ultimately positioning the country as a leader in sustainable battery production and management.

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BATPOWER
Preparation of the VET sector on battery energy transition

BatPower: Preparation of the VET sector on battery energy transition

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Hungary: Identification of specific gaps and needs in battery energy education

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Executive Summary

Battery manufacturing requires specialized technological and engineering knowledge, which Hungarian vocational and higher education institutions currently cannot provide at a sufficient depth. The shortage of skilled professionals is a significant issue, particularly in electrical engineering, mechatronics, and chemical industries, where the labor market is experiencing an increasing demand for workers with appropriate expertise. Industrial stakeholders frequently express concerns that recent graduates lack sufficient practical experience in battery cell manufacturing, assembly, and recycling, making their immediate employment challenging and reducing productivity. The curricula of educational institutions fail to keep pace with the rapid advancements in the industry, leading to substantial knowledge gaps among graduates.

The dual training system does not provide students with adequate industrial experience, as collaboration between battery manufacturers and educational institutions is not strong enough. As a result, students have only limited access to the practical knowledge essential for successful integration into the workforce. The transition from the automotive industry to battery manufacturing presents an additional challenge, as workers specialized in internal combustion engine production are being retrained at a slow pace, and further training opportunities are severely limited.

Another shortfall of the education system is the lack of in-depth coverage of battery lifespan and safety knowledge in curricula. The teaching of energy storage systems, diagnostic procedures, and industrial safety regulations does not receive sufficient emphasis, despite being essential for professionals working in the sector.

Practical training is also inadequate, as students have few opportunities to experience the real-world application of battery technology in an industrial environment. A significant portion of the latest industry knowledge is only available in English or German, posing a serious obstacle for both educators and students. This language barrier hinders access to new knowledge and the integration of the most advanced technologies into education.

To effectively transfer modern battery technology knowledge, updating training programs and providing continuous professional development for educators is essential. However, currently, such professional training opportunities are only available to a limited extent, preventing educators from keeping up with industry developments.

To improve education, it is necessary to develop modern educational materials and establish effective collaboration strategies between educational institutions and industry stakeholders. Many vocational institutions lack the appropriate laboratory infrastructure, further complicating practical education. The absence of electric and hybrid vehicles, as well as battery diagnostic tools, prevents students from acquiring the essential skills needed in the industry through real-world applications. Ensuring the necessary infrastructure is critical to preparing future professionals for the battery industry's labor market.

Introduction

1. Context

Battery energy technologies play a crucial role in the European Union's Green Deal and the achievement of energy transition goals. In July 2021, the EU introduced the *Fit for 55* package, which aims to reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. The package includes several measures to decarbonize the transportation sector, with a strong focus on promoting electromobility, which is closely linked to the rapid advancement of battery technology. Improving energy storage efficiency is essential not only for achieving sustainable transportation but also for the reliable integration of renewable energy sources.

2. Challanges

The current vocational and higher education systems are struggling to keep pace with industry expectations, hindering the supply of adequately trained professionals. Industrial stakeholders face significant challenges in the production, operation, and maintenance of electric vehicles, including:

- Labor shortage: With the rise of electromobility, industry forecasts indicate that at least 40,000 professionals will need to be retrained by 2025. However, the current education system does not produce a sufficient number of specialists equipped with the necessary expertise in new technologies.
- Handling high-voltage systems: The maintenance of batteries and high-voltage systems poses significant safety risks. In Hungary, there is currently no standardized certification system in this field, making it difficult to train and employ qualified professionals.
- Deficiencies in dual training programs: Collaboration with industrial partners is often inconsistent and unstructured, preventing students from gaining sufficient hands-on experience. The links between educational institutions and companies are not strong enough to effectively support practical training.

- Issues in information flow: Industrial stakeholders frequently lack proper feedback on the content of vocational training programs. As a result, education does not adapt flexibly to industry needs, further widening the gap between training and labor market demands.

3. Objective

The aim of this research is to identify the gaps in battery technology education and propose recommendations to improve workforce preparedness. To achieve this, the following specific objectives have been defined:

- **Identifying discrepancies** between the vocational training system and industry expectations, with a particular focus on battery technology education.
- **Enhancing dual training programs** to ensure that students gain as much hands-on experience in industrial environments as possible.
- **Supporting the upskilling of educators** to enable the effective teaching and integration of new technologies into the education system.
- **Facilitating workforce adaptation**, allowing existing professionals to transition more easily into the fields of electromobility and battery technology.

By implementing these measures, the vocational education system can better align with industry requirements, fostering innovation and ensuring a competitive workforce for the battery sector.

Methodology

The purpose of this research is to identify gaps between battery technology education and labor market expectations and to propose recommendations that facilitate workforce adaptation to this rapidly evolving industry. The research process relies on various data sources and methodological approaches to ensure a comprehensive and reliable analysis.

1. Sources of Data:

The research was based on two primary data collection methods:

- **Secondary research (Desk research):** To explore industry trends and vocational education challenges, an extensive review of literature and documents was conducted. This included analyzing relevant industry reports, vocational education documents, international and national studies, as well as educational and industrial collaboration strategies. Special attention was given to the labor market situation of the Hungarian battery industry and the current state of the vocational training system.
- **Qualitative data collection**: Structured interviews were conducted with industry stakeholders, representatives of vocational training institutions, and educators. The objective was to gain direct insights into industry experiences, identify gaps between education and labor market needs, and explore opportunities for improvement.

2. Focus Areas

The research focused on three key areas:

- **Technical knowledge and industry expertise:** Analyzing educational content related to battery operation, manufacturing, testing, and recycling. The study assessed how well current vocational training programs align with industry-specific requirements and identified areas where improvements are needed.
- **Development of practical skills:** Evaluating the effectiveness of dual training programs, practical training facilities, and collaborations with industry partners. Based on industry feedback, the study examined to what extent current training programs provide students with hands-on experience.
- **Soft skills and labor market expectations:** Examining the role of problem-solving abilities, teamwork, project management, and adaptability in an industrial setting. The research identified how these skills are currently taught in vocational training programs and explored opportunities for further development.

The findings indicate that Hungary's vocational training system does not yet fully meet the requirements of the battery industry. Based on feedback from industry stakeholders and

international best practices, specific recommendations have been formulated to bridge the gap between education and industry. These insights can contribute to the modernization of educational programs, the continuous training of educators, and the enhancement of industrial collaboration.

Review of Current Programs and Gaps

1. Overview of Existing Programs

With the rise of battery technology and electromobility, educational institutions must continuously adapt to rapidly changing industry requirements. In Hungary, several vocational and higher education institutions offer battery technology training; however, current programs still exhibit significant gaps in several areas.

National Battery Industry Strategy 2030:

- The Hungarian government has set the strategic goal of ensuring a skilled workforce at all levels of the battery industry. Forecasts indicate that by 2025, at least 40,000 workers will need retraining to meet industry demands. Key initiatives of the strategy include:
    - Launching new vocational and adult education programs in battery technology.
    - Expanding dual training models through collaborations between higher education institutions and industry stakeholders.
    - Joining international training programs, such as the *European Battery Alliance* and the *ALBATTS* project.

Higher Education and Research Collaborations:

- **Budapest University of Technology and Economics (BME):** A key national hub for electric drivetrain and battery technology research.
- **Széchenyi István University (Győr):** Through its Vehicle Industry Research Center, the university plays a major role in the industrial application of battery technology.

- **HUN-REN Energy Research Centre:** Specializes in energy storage and recycling technologies.
- **University of Debrecen:** Collaborates with CATL to develop battery technology programs and laboratories.
- **Pannon University:** Focuses on the development of sustainable battery manufacturing technologies.

These institutions play a crucial role in advancing battery technology in Hungary. However, there remains a significant gap between university education and industrial applications, highlighting the need for closer collaboration and curriculum alignment with industry expectations.

2. Key Educational Gaps

The rapid advancement of battery technology requires increasingly complex technical and practical expertise from professionals in the industry. However, current vocational training programs do not fully meet industry requirements in several key areas.

2.1.Deficiencies in Technical Knowledge

1. **Limited knowledge of battery chemistry and structure**
    - Educational programs do not cover the electrochemical processes of battery cells in sufficient depth.
    - The detailed working principles of different battery types (e.g., lithium-ion, solid-state, sodium-ion) are missing from training programs.

2. **Inadequate education on safety protocols and battery lifecycle management**
    - Improper handling of batteries poses safety risks, yet occupational safety procedures receive insufficient emphasis.

- Lifecycle management principles, such as optimizing battery lifespan and predicting failures, do not receive adequate attention.

3. **Lack of training in battery diagnostics and monitoring systems**
   - The curriculum does not adequately prepare students for the operation of battery management systems (BMS).
   - Key concepts such as cell balancing and battery degradation monitoring are not covered in sufficient detail.

4. **Outdated or incomplete education on industrial standards and manufacturing processes**
   - The teaching of quality assurance and manufacturing processes used in the industry is inadequate.
   - The steps of industrial battery cell and module assembly and testing are not an integral part of the curriculum.

5. **Lack of education on recycling and sustainability**
   - Training on industrial procedures related to battery recycling and disposal is insufficient.

6. **Difficulties in adapting to industry standards**
   - Educational institutions struggle to keep pace with rapidly evolving industry requirements.
   - Due to continuous technological advancements, curricula quickly become outdated, creating additional challenges for both educators and students.

2.2.Deficiencies in practical skills

1. **Insufficient practical experience in battery assembly, testing, and recycling**

- Students do not have access to modern industrial production lines that would allow them to familiarize themselves with assembly technologies.

2. **Lack of use of modern tools and simulation technologies**
   - There are limited opportunities in education for real-time simulations and virtual laboratories.
   - The handling of industrial measuring instruments and testing equipment is not adequately covered in practical training.

3. **Limited availability of internships and industry experience opportunities**
   - Dual training programs do not provide sufficient industrial collaboration opportunities, making it difficult for students to gain real-world industry experience.
   - The organization of internships is often not coordinated with industry stakeholders, preventing students from receiving adequate preparation for the labor market.

4. **Lack of practical training in battery recycling and sustainability**
   - Educational institutions lack appropriate laboratory environments for hands-on training in battery disassembly and recycling.
   - The practical aspects of sustainable battery management (e.g., recovering secondary raw materials) are not sufficiently emphasized in training programs.

2.3.Lack of soft skills development

1. **Lack of education in project management and industrial process control**
   - The demand for effective project management knowledge is increasing in industrial environments, yet it is not an integral part of vocational training programs.

- Students do not receive adequate training in planning, scheduling, and efficiently managing industrial workflows.

2. **Lack of preparation for green technologies and sustainable industrial processes**
   - The application of sustainable business models and circular economy principles is not taught in sufficient depth.
   - Students do not receive training on industrial energy efficiency strategies or technologies aimed at reducing carbon footprints.

3. **Lack of development in problem-solving and critical thinking skills**
   - Training programs do not place enough emphasis on developing students' independent problem-solving skills, despite the need for quick decision-making in industrial environments.
   - Students do not learn how to handle unexpected technical issues or optimize manufacturing processes.

4. **Lack of communication and collaboration skills development**
   - Clear communication and effective teamwork are essential in industrial workplaces, yet they are not adequately addressed in vocational training.
   - Students are not prepared to collaborate with engineers and technicians from different specialties in an industrial setting.

5. **Lack of digital competencies and industrial automation knowledge**
   - Digital technologies (e.g., IoT, artificial intelligence, industrial automation) are playing an increasingly important role in the industry, but their education is currently insufficient.
   - Students do not gain enough hands-on experience in using industrial software and digital manufacturing management systems.

6. **Lack of adaptability and innovation skills development**

- Due to the rapid changes in industry trends, employees must be flexible, yet vocational education does not provide sufficient training in innovative thinking and adaptability.
- Self-learning strategies and methods necessary for quickly acquiring new technologies are not incorporated into education.

3. Regional Challanges

Hungary has become one of Europe's key hubs for battery manufacturing in recent years; however, the education system has not yet fully adapted to the industry's rapid development. Battery technology education is unevenly integrated across different training levels and institutions, which hinders the effective fulfillment of the sector's workforce demands.

3.1. Deficiencies in vocational and technical training

The current vocational training system only partially incorporates battery technology knowledge. Existing programs primarily focus on the maintenance and servicing of electric and hybrid vehicles but do not provide sufficiently detailed education on battery manufacturing, diagnostics, and recycling.

3.2. Limitations of higher education and research

Several universities in Hungary are engaged in battery technology research and education, including the **Budapest University of Technology and Economics (BME), Széchenyi István University (Győr), the University of Debrecen, and Pannon University**. These institutions primarily focus on research and development to improve battery efficiency. However, according to industry stakeholders, there remains a significant gap between university education and real industrial expectations.

Industry representatives often express concerns that graduating engineers lack adequate practical knowledge in battery cell assembly and recycling. This is largely due to the fact that

practical training is often insufficient, as university laboratories and experimental infrastructures are not always equipped to simulate real industrial conditions.

3.3. Deficiencies in dual training and industry collaboration

The Hungarian dual training system is already in place in some areas related to the battery industry, but according to industry stakeholders, it is still not sufficiently effective. Collaborations are often ad hoc, and there are no standardized guidelines on what specific practical experience students should gain from their industrial partners.

Cooperation between vocational training institutions and industry stakeholders frequently encounters communication issues. Industrial companies do not receive precise feedback on the curriculum taught in schools, while educational institutions lack adequate insights into industry expectations.

4. Identification of Needs

4.1. Needs of students

The advancement of battery technology imposes new requirements on vocational and higher education systems, making it essential to provide students with modern curricula and practical learning opportunities.

- **Access to up-to-date, hands-on learning tools** (simulations, case studies, digital labs).
- **Stronger industry collaboration** to enable real-world work experience in industrial environments.
- **Improved knowledge transfer** to ensure research findings reach industry stakeholders more efficiently.
- **Reduction of regulatory barriers** that slow down the market introduction and industrial application of new technologies.

4.2.Needs of Educators

For educators, it is essential to have access to the latest technological advancements and the necessary tools to effectively teach battery technology.

- **Providing training programs** on the latest developments in battery technology (safety, lifecycle management, recycling).
- **Encouraging university-industry collaborations** to better align education with industry needs.
- **Access to modern educational resources and tools** to enhance practical training.
- **Strengthening international collaborations** to ensure educators stay up to date with the latest industry knowledge.

4.3.Industry needs

For the industry, it is crucial to have professionals with the necessary expertise in battery assembly, testing, and operation.

- **Ensuring a skilled workforce** capable of handling battery assembly, testing, and management systems.
- **Enhancing practical knowledge**, with a strong focus on battery diagnostics and industry standards.
- **Implementing short-term training programmes** to help the existing workforce swiftly adapt to new technologies.

A strong collaboration between education and industry, updated curricula, and improved hands-on training are essential for the sector's sustainable growth.

5. Recommendations for Interventions

5.1.Development of educational materials

To enhance the effectiveness of battery technology education, it is essential to develop modern and standardized curricula that align with industry expectations and safety requirements.

- **Development of modules covering:**
  - The fundamental operation of batteries.
  - Recycling technologies and sustainability aspects.
  - Safety protocols and industry standards.

- **Practical manuals and interactive digital tools for vocational training programmes:**
  - Development of practice-oriented materials with industry involvement.
  - Implementation of simulation systems to ensure safe training, particularly for hazardous work processes.

- **Encouraging industry collaboration in curriculum development:**
  - Companies can define the specific knowledge and skills they expect from employees.
  - Countries involved should coordinate requirements to support standardisation.

5.2. Training programmes

To ensure effective education, continuous training for educators and professionals is essential.

- **Training for educators:**
  - Organising training sessions and workshops focused on the latest developments and industrial applications of battery technology.
  - Ensuring that educators understand the entire process and its implications based on different job roles and responsibilities, enabling them to transfer knowledge effectively.

- **Short-term certification courses for students and professionals:**
  - Designing targeted training programmes based on existing industry competencies.

- Developing specialised modules on battery manufacturing, maintenance, and recycling.

5.3. Industry collaborations

Close collaboration with companies is essential to align education with labor market expectations.

- **Establishing partnerships with industry stakeholders**
  - Providing practical training placements where students can acquire necessary skills in real work environments.
  - Integrating industry-required knowledge into education to ensure immediate workforce applicability.
- **Incorporating real-world case studies into curricula**
  - Embedding industry-specific challenges and solutions into training programmes.
  - Encouraging industry stakeholders to share essential knowledge on safety and quality assurance with employees.

For the industry's growth and a more effective education system, strong cooperation among industry stakeholders, educational institutions, and regulatory authorities is crucial. Standardized curricula, enhanced practical training, and short-term upskilling programmes can help address labor shortages and improve competitiveness in the battery technology sector.

6. Conclusion

The research has identified key gaps in battery industry education, particularly in technical knowledge, practical skills, and soft skills. Current training programmes struggle to keep up with the rapid advancements in the industry, leaving students with insufficient hands-on experience and limiting professional development opportunities for educators. Industry stakeholders highlight that new workers are not adequately prepared for battery cell manufacturing, testing, and recycling.

The proposed interventions focus on three main areas: curriculum development, educator training, and strengthening industry collaboration. Educational modules related to batteries need to be expanded to include safety regulations, recycling technologies, and sustainability principles. Modern training programmes must be provided for educators, while partnerships with companies should offer students real-world industrial experience.

The next steps involve the practical implementation of these interventions, including establishing partnerships with industry stakeholders, improving the technical infrastructure of educational institutions, and providing targeted training for professionals. These changes are essential to ensuring that Hungary develops a skilled and competitive workforce for the battery industry.

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BATPOWER
Preparation of the VET sector on battery energy transition

BatPower: Preparation of the VET sector on battery energy transition

2024-1-SK01-KA220-VET-000256192

WP2/A2.1: Desk research on gaps and needs for the battery energy education within the secondary VET level in Italy

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1. Executive summary

The BatPower project aims to bridge the gap between vocational education and training (VET) and the growing battery industry in Italy. As the country accelerates its transition toward sustainable energy, the demand for professionals skilled in battery manufacturing, integration, diagnostics, and recycling is increasing rapidly. However, the current education and training system is not fully aligned with these emerging needs. BatPower seeks to identify the key challenges and propose concrete, implementable solutions that can strengthen the connection between education and industry and support the development of a future-ready workforce.

This report provides an in-depth analysis of the existing gaps in battery-related training in Italy.

The analysis is focused on three key dimensions:

- **Technical knowledge**: Current programs, especially at the VET and ITS levels, often lack modules on advanced battery topics such as cell chemistry, battery management systems (BMS), safety protocols, second-life applications, and recycling technologies.
- **Practical skills**: Training institutions frequently face constraints in offering hands-on experience. Access to specialized laboratories and equipment is limited, and work-based learning opportunities—such as structured internships or apprenticeships in battery-related roles—remain sporadic and fragmented.

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- **Transversal skills**: Competencies such as project management, interdisciplinary collaboration, critical thinking, and digital literacy are often underdeveloped in traditional technical programs, despite being essential for working in dynamic, innovation-driven environments.

Building on this assessment, the report proposes a series of targeted interventions structured around three pillars:

- **Curriculum development**: creation of modular content covering battery technologies, recycling, safety, and lifecycle management, supported by both physical and digital training tools.
- **Training programs for educators and professionals**: introduction of short-term certification paths, train-the-trainer workshops, and upskilling modules tailored to the evolving demands of the battery sector.
- **Industry collaboration**: strengthening partnerships with companies for student placements, co-design of course content, access to real-world equipment, and integration of industrial case studies into the learning process.

These recommendations are designed to be realistic and actionable at the institutional and regional levels, without requiring structural policy reform. The ultimate goal is to foster a more responsive, connected, and innovative training ecosystem that will enable Italy to play a leading role in the European battery value chain—while offering meaningful employment opportunities in a strategic and growing sector.

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2. Introduction

Battery energy technologies play a central role in achieving the European Union's strategic goals for climate neutrality, energy security, and sustainable industrial development. As outlined in the EU Green Deal and reinforced through the REPowerEU plan, batteries are not only essential for decarbonizing transport and enabling renewable energy storage, but also represent a key industrial value chain where Europe seeks to gain technological sovereignty. Italy, with its strong manufacturing base and growing investment in electric mobility and energy transition, has a unique opportunity to contribute to this transformation—provided that the country can equip its workforce with the right skills.

However, **a number of challenges hinder this ambition**. The current structure of vocational education and training (VET) as well as higher education programs in Italy often fails to reflect the evolving needs of the battery industry. Training curricula tend to focus on general electrical or mechanical competencies, without delving into specialized topics such as battery chemistry, diagnostics, safety protocols, or circular economy principles. Moreover, there is a shortage of practical learning opportunities: laboratories with appropriate equipment are limited, internships are not consistently offered or structured, and collaboration between schools and companies remains fragmented. These gaps risk creating a mismatch between the skills of new graduates and the real-world demands of companies involved in battery design, production, integration, and recycling.

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The **objective** of this report is to **conduct a detailed mapping of the current educational offer and to identify the main gaps that limit the development of a skilled workforce in the Italian battery sector**. Rather than providing a general overview, the report focuses on three critical dimensions: the depth and specificity of technical knowledge, the availability and quality of practical, hands-on training, and the presence of essential transversal skills, such as project management and interdisciplinary collaboration. The analysis seeks to understand how these gaps manifest across different levels of education—particularly within VET institutions and ITS Academies—and to what extent they are aligned with the actual needs of companies working in battery design, production, integration, and end-of-life management. Building on this diagnosis, the report offers concrete and actionable recommendations aimed at strengthening the connection between education providers and industry, modernizing curricula, upgrading training infrastructure, and supporting teachers and learners in acquiring future-proof competencies. The overarching goal is to support the development of an effective and inclusive training ecosystem that can sustain Italy's role in the European battery value chain.

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3. Methodology

3.1 Data Sources

This study is based on a structured documentary analysis, with the aim of clearly and concretely identifying gaps and needs in technical and vocational training in the battery sector in Italy.

The sources consulted include a variety of institutional documents, scenario analyses and operational materials useful for understanding the current training context.

In particular, the following were examined:

- National reports and studies on the labour market, which provide an up-to-date overview of the demand for skills in the energy, sustainable mobility and advanced manufacturing sectors, with a specific focus on emerging technical profiles.
- Analyses and monitoring of vocational training, in particular documents analysing the training offer of ITS, the use of apprenticeships, and the school-to-work transition modalities.
- Statistical and forecasting sources, which help to assess the evolution of labour demand, the difficulty of finding specific skills and employment trends in the short and medium term.
- Material is available through the ECOLE network in the confindustrial system, which includes data, analyses of vocational needs, territorial observatories, internal reports from member companies and up-to-date

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information on active VET and ITS programmes in cooperation with the manufacturing world. Thanks to this network, it was possible to supplement the public documentation with concrete evidence from real training experiences and the needs expressed by enterprises.

3.2 Focus areas

The analysis focuses on Italy, examining how battery technology content is integrated in technical and vocational education programmes, both at regional and national level. In particular, the work paid attention to the coherence between existing educational pathways and the real needs of companies active in the electric mobility, energy storage and circular economy sectors.

The training gap was analysed on three distinct but complementary levels:

Technical knowledge, i.e. the presence (or absence) of specific content in curricula related to battery chemistry, life cycle management, safety protocols, regulations and new technologies (e.g. solid state, second-life batteries). This level is essential to provide students with up-to-date and contextualised knowledge with respect to the evolution of the industry.

Practical skills, i.e. the operational skills that are acquired through laboratory experiences, internships, apprenticeships and the use of specific tools for testing, diagnostics, assembly or disposal. These skills are essential to meet the demand for technical profiles that can be immediately inserted in production contexts.

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Soft skills, which include transversal skills such as problem solving, interdisciplinary collaboration, project management and sensitivity to ecological transitions. These skills, which are often neglected in technical-scientific pathways, are nowadays central for effective integration into company teams and for dealing flexibly with technological and organisational changes.

This subdivision has been adopted in order to facilitate the critical reading of needs, to propose targeted interventions and to promote an integrated view of the skills needed to operate along the entire battery chain.

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4. Review of Current Programs and Gaps

4.1 Overview of Existing Programs in Italy

In Italy, vocational education and training (VET) and higher education programs related to battery technology are still evolving. While there are **various university programs** focused on energy storage and battery-related research, vocational training specifically tailored to battery manufacturing, safety, and lifecycle management remains **limited**.

The **main players** currently offering courses and conducting research in this field are **universities**, which provide advanced programs and high-profile specializations. Among the most active institutions are Politecnico di Milano, Sapienza University of Rome, the University of Bologna, Politecnico di Torino, and the University of Naples Federico II.

Politecnico di Milano, for example, offers a **Master in Energy Engineering**, covering advanced topics in **energy storage technologies, battery materials, and grid integration**.

Sapienza University of Rome provides a **Master in Electrical Engineering** with modules on **energy storage systems**, while the **University of Bologna** features a **Sustainable Energy Engineering program** that includes **batteries and renewable energy integration**.

Politecnico di Torino, within its Automotive Engineering program, collaborates with leading companies in the sector to develop integrated training pathways.

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The University of Naples Federico II also has a research group specialized in battery degradation issues and applications for electric transport.

At the same time, more **vocationally oriented opportunities are emerging**, with particular emphasis on hands-on training for technicians and operators. In this context, the Fondazione ITS Academy Mobilità Sostenibile Aerospazio/ Meccatronica Piemonte stands out with its "**E-MOBILITY – Higher Technician for the Efficiency, Production, and Maintenance of Vehicles**" course, which provides an exemplary model of specialized training aimed at meeting real-world industry needs and guiding students toward professional profiles aligned with the challenges of electric mobility.

A distinctive feature of this ITS program is the **strong integration of theory and practice**. On the one hand, students delve into crucial topics like **batteries, battery management systems, and electric motors**; on the other, they work on concrete projects, acquiring skills that are immediately applicable in the workforce. This approach reflects Italy's broader effort to bridge the skills gap in the electric battery sector, building on both the excellence of its universities and the synergy between businesses and higher technical institutes.

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Good Practice: The "E-MOBILITY" ITS Course

- **Provider**: Fondazione ITS Academy Mobilità Sostenibile Aerospazio/Meccatronica Piemonte
- **Duration and Structure**: two-year program (2024-2026), totalling 1.800 hours, of which about half are spent in-company
- **Credential Awarded**: EQF Level 5 Diploma
- **Goal**: to train technicians capable of tackling electric mobility challenges, with cross-functional skills in mechatronics, technical drawing, technical English, business management, and public speaking
- **Practical Approach**: hands-on workshops and field projects (including the design and construction of electric go-karts equipped with telemetry sensors)
- **Target Audience**: high school graduates and young/adult learners aiming to enter the e-mobility and advanced technology sectors

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Although numerous high-quality programs are in place, there is still **a clear need to bridge the gap between theoretical learning and hands-on application**. At the same time, academic institutions are showing a growing interest in battery technologies, businesses are increasingly collaborating with the education sector, and ITS programs are playing a more prominent role. Taken together, these factors point to a **favourable trajectory for the broader training ecosystem around electric batteries**. Moving forward, a **key priority will be the creation of specialized training pathways** that adapt to evolving technologies and address the increasingly sophisticated demands of this rapidly expanding sector.

4.2 Key educational gaps in Italy

The analysis of current educational offerings in Italy has revealed several persistent gaps that hinder the development of a workforce equipped to meet the growing needs of the battery industry. These gaps span technical knowledge, practical training, and cross-cutting competencies.

Technical Knowledge

While some university programs cover advanced topics related to energy systems and electrochemistry, battery-specific modules are often absent or only superficially addressed in VET curricula. Topics such as lithium-ion battery chemistry, thermal management, safety protocols, and lifecycle assessment are rarely taught in an integrated or comprehensive manner. Furthermore, training on newer technologies, such as solid-state batteries and

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supercapacitors, remains limited and primarily confined to research-level settings.

Practical Skills and Laboratory Access

A key challenge in battery education is the limited access to advanced laboratories and diagnostic tools. Although leading universities—such as the University of Bologna (E-Cells Lab), Politecnico di Milano (EN:Lab), and the University of Pavia (R²BATT)—have recently established well-equipped labs for hands-on research on lithium-ion and recycling technologies, these facilities remain exceptional rather than standard. In many other institutions, particularly within the VET and ITS sectors, laboratory infrastructure is outdated or not specifically designed for battery testing and management systems. Equipment such as battery cell testers, pack simulation software, and battery management system (BMS) tools are rarely available in standard teaching environments.

This disparity in access to practical training environments limits students' ability to apply theoretical knowledge in realistic contexts. ITS programs in sustainable mobility have made progress through partnerships with industry, acquiring EV components and diagnostic devices for student use. However, a 2023 review indicated that many ITS and VET institutions still lack modern battery-specific tools, hindering the development of essential technical skills.

Industry Exposure and Work-Based Learning

Another significant educational gap concerns the availability and quality of internships and apprenticeships. Although formal apprenticeship contracts are

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used in Italy, especially in regions with strong industrial presence, their adoption within the battery sector remains limited. According to data from Unioncamere and ANPAL, only a small proportion of students in ITS programs are currently engaged in structured, battery-related apprenticeships.

Internships in the battery field are also unevenly distributed. In industrial regions such as Piedmont and Emilia-Romagna, partnerships with companies such as Stellantis or Enel X support student placements. However, in many other areas, such experiences are rare, unstructured, or unpaid—making it difficult for students to gain real-world competencies and reducing their motivation to pursue careers in battery technology.

These weaknesses are compounded by a general lack of alignment between education and industry. Companies are not always involved in curriculum design or student evaluation, and many small and medium enterprises lack the capacity or incentive to host students in meaningful training roles. Although national programs like the "Rete E-Mobility" and ITS Foundation governance models promote collaboration, the overall level of engagement remains fragmented.

Soft Skills and Interdisciplinary Competence

Finally, soft skills such as project management, teamwork, and the ability to work across disciplines are often underemphasized in technical programs. This is particularly problematic in a sector like batteries, where effective collaboration between engineers, software developers, and production teams

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is crucial. Few programs offer structured training in these areas or integrate interdisciplinary project work into the curriculum.

Addressing these educational gaps—particularly in terms of access to hands-on training, structured workplace learning, and cooperation between industry and educational institutions—is essential for developing a skilled workforce capable of supporting the battery sector's rapid growth and innovation.

Category	**Identified Gaps**
Technical Knowledge	Lack of training on battery safety, lifecycle, and sustainability.
Practical Skills	Limited laboratory access, lack of hands-on battery testing.
Soft Skills	Absence of project management and interdisciplinary collaboration training.
Industry Collaboration	Weak ties between VET institutions and battery companies, few apprenticeship opportunities.
Regional Disparities	Stronger industry presence in the North; fewer opportunities in the South.

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4.3 Regional Challenges in Battery Education

The development of battery education programs in Italy is influenced by the distribution of industrial ecosystems and educational infrastructures across regions. While it is true that disparities exist, these should not be interpreted as static gaps, but rather as contextual differences that inform how and where certain interventions may be most effective.

Northern regions such as Piedmont, Lombardy, Veneto, and Emilia-Romagna benefit from a well-established industrial base in the automotive and energy sectors, as well as the presence of technical universities and research centers. These regions host major actors in the battery value chain—including FAAM, and Enel X—and have initiated advanced projects in battery recycling, fast-charging infrastructure, and electric vehicle development. Consequently, students in these areas have comparatively greater access to internships, apprenticeship opportunities, and updated laboratory facilities.

Central and Southern regions (e.g., Lazio, Campania, Apulia, Sicily), while traditionally less industrialized in this specific sector, are increasingly involved in initiatives linked to battery technology and sustainable mobility. Universities such as Sapienza and the University of Naples Federico II conduct relevant research in battery recycling and grid storage. Moreover, EU-funded regional development programs are progressively supporting the creation of new VET programs and innovation hubs in these areas.

Rather than focusing solely on the imbalance of opportunities, it is more constructive to acknowledge that different regions present different entry

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points for intervention. In the North, efforts may focus on scaling and systematizing existing collaborations, while in the South and Center, priorities may include the creation of new laboratories, training partnerships, and exposure to industrial practice.

Overall, regional differences underscore the need for a place-based approach to the development of battery-related education, ensuring that both existing strengths and emerging opportunities are supported through targeted policy, funding, and stakeholder collaboration.

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5. Identification of needs

The analysis of training programs in Italy has highlighted **significant gaps** in technical knowledge, practical skills, and collaboration between the education sector and industry. This chapter explores the **specific needs of students, educators, and companies**, aiming to identify targeted interventions to improve the training offer in the battery sector.

5.1 Needs of Students

Italian students enrolled in energy, electrical, and technical programs face several barriers to acquiring the full set of skills needed in the battery sector. One major challenge is the limited access to hands-on training with advanced equipment. While flagship universities and some ITS academies are equipped with battery testing tools, simulation software, and diagnostic devices, such resources remain the exception rather than the rule. Most students do not have the opportunity to work directly with lithium-ion cell testers, battery management systems (BMS), or simulation platforms essential for battery pack design and optimization.

This lack of equipment is compounded by a mismatch between the theoretical content delivered in many programs and the practical skills required in the workplace. University programs often prioritize theory without offering laboratory components tailored to battery technologies, while many VET and ITS pathways still lack dedicated modules on batteries, recycling, safety protocols, or second-life applications.

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Moreover, opportunities for real-world experience remain limited. Internships and apprenticeships in the battery sector are not systematically offered and are often confined to northern industrial regions. According to Unioncamere, less than one-third of firms are actively involved in hosting students through school-to-work pathways, and battery-focused internships are a niche within that share. Many students report difficulties in securing placements that are paid, structured, and relevant to their studies—factors that reduce motivation and hinder professional development in this emerging field.

To respond to these challenges, several needs have emerged:

- Expanded access to both digital and physical laboratories equipped for battery diagnostics and safety testing.
- Integration of hybrid learning modules that combine theory with practice, particularly in VET and ITS settings.
- Stronger partnerships with companies to offer paid, structured internships and apprenticeships focused specifically on battery-related applications.
- Career orientation and mentorship initiatives to help students understand the full spectrum of roles and competencies within the battery value chain.

5.2 Needs of Educators

Educators play a central role in equipping future professionals with the skills needed to succeed in the battery sector, yet they often face systemic barriers to doing so effectively. Many teaching staff, particularly in vocational and

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technical education, lack access to up-to-date information and hands-on training on emerging technologies such as lithium-ion batteries, battery management systems (BMS), and battery recycling processes.

This gap is compounded by a shortage of continuous professional development (CPD) opportunities tailored to the needs of battery education. Few structured upskilling pathways are available for instructors, and those that exist tend to be project-based or one-off initiatives, with limited continuity. As a result, many educators are unable to integrate cutting-edge industry knowledge or updated practices into their teaching. In addition, the rapid evolution of battery technologies and the shift toward electric mobility require ongoing curricular innovation, which is difficult to implement without proper training and institutional support.

There is also a need for better access to modern teaching resources. Many institutions still rely on outdated or generic materials that do not reflect the specific demands of the battery sector. Furthermore, interdisciplinary and digital teaching tools, such as interactive simulations or virtual labs, are not yet widely adopted despite their potential to enrich the learning experience.

Key needs identified for educators include:

- Structured upskilling programs on battery technology, safety, lifecycle management, and sustainability.
- Access to updated teaching materials developed in collaboration with industry experts.

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- Opportunities for direct engagement with battery research and innovation hubs.
- Inclusion in collaborative networks that connect educators, researchers, and industrial partners for ongoing curriculum development.
- Addressing these needs is vital to ensure that teaching staff remain aligned with technological advancements and can deliver high-quality, relevant education to students entering the battery sector.

5.3 Industry Needs

As the battery sector in Italy and across Europe grows rapidly, companies are facing increasing pressure to find qualified personnel with a mix of technical, operational, and transversal skills. Businesses operating in battery production, electric mobility, and energy storage need professionals who are not only well-versed in battery chemistry and management systems, but who also have experience with diagnostics, quality control, automation, and safety protocols.

A recurrent need expressed by industry stakeholders is the difficulty in recruiting technicians with hands-on experience in battery cell assembly, testing procedures, and battery management system integration. Even where universities and ITS institutions are training students in related disciplines, there is often a gap between educational outcomes and the skills immediately applicable in industrial contexts. In particular, the fast-paced evolution of battery technologies and the need for compliance with strict safety and sustainability regulations require continual alignment between training content and operational realities.

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Moreover, companies report a need for short-term upskilling programs to adapt the existing workforce to new roles in battery diagnostics, second-life evaluation, and circular economy models. This is especially relevant for SMEs, which may lack internal capacity for dedicated training and rely on external support for workforce development.

Another important issue concerns industry participation in education and training governance. While many companies are involved in ITS foundations or host internships, the overall level of engagement remains fragmented. There is a need for more systematic collaboration in curriculum co-design, joint project development, and equipment sharing to ensure that students are trained on real technologies and workflows.

Key needs from the industry perspective include:

- Technicians and engineers with practical skills in battery assembly, testing, maintenance, and recycling.
- Training modules that reflect industrial standards and operational safety norms.
- Opportunities for reskilling and upskilling of current employees in battery-related roles.
- Stronger partnerships with educational institutions to co-design and deliver training programs aligned with actual production and innovation needs.
- Meeting these needs will be critical not only for closing the skills gap, but also for ensuring that Italy's battery industry remains competitive and

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resilient in the face of technological transformation and global supply chain shifts.

6. Recommendations for Interventions

Based on the gaps and needs identified in previous chapters, this section proposes concrete and actionable interventions to strengthen battery-related education and training in Italy. The recommendations focus on three key areas: the development of educational materials, the creation of targeted training programs, and the reinforcement of collaboration between industry and education.

6.1 Development of educational materials

To modernize existing curricula and support competency-based learning, it is essential to provide updated, modular, and practical educational resources tailored to the evolving needs of the battery sector.

Curriculum modernization in VET and higher education should include dedicated modules on:

- Battery chemistry (LFP, NMC, sodium-ion, solid-state)
- Lifecycle management and recycling
- Safety and thermal risk prevention
- AI and digital diagnostics tools for battery monitoring and optimization

Digital and physical learning tools should be developed to facilitate practical training:

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- Virtual labs and battery simulators for assembly, diagnostics, and testing
- Manuals for safe recycling and second-life applications
- Use of AI-driven platforms for failure prediction and BMS configuration

Laboratory upgrades should focus on providing access to:

- Battery cell testing devices and charging/discharging simulators
- BMS integration benches and thermal monitoring systems
- Modules for battery disassembly and recycling processes

Co-development with industry is encouraged to ensure relevance:

- Training manuals enriched with real case studies and industrial procedures
- Shared safety protocols for handling lithium-ion and solid-state batteries

6.2 Training programs for educators and professionals

Given the rapid evolution of the battery sector, there is a pressing need to continuously update the skills of both educators and professionals.

Train-the-trainer programs for VET educators should include:

- Workshops on emerging battery technologies, regulatory frameworks, and circular economy
- Practical labs on battery testing, pack assembly, and safety simulation
- Certification pathways to ensure teaching quality and consistency

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Upskilling and reskilling programs for workers should be designed as:

- Short-term, stackable modules combining online theory and in-person lab experience
- Specializations in BMS integration, diagnostics, and sustainable manufacturing
- Joint courses with industrial partners hosted in real production or testing environments

6.3 Strengthening industry collaboration

Closer collaboration between companies and education providers is key to ensuring that training programs reflect real production processes, safety standards, and innovation practices.

Partnerships with companies and integration of real-world case studies

To ensure that battery-related training pathways are aligned with industry standards and effectively prepare students for employment, it is crucial to establish structured and ongoing partnerships between educational institutions and companies operating across the battery value chain. These partnerships should move beyond occasional internships and aim to integrate companies into the educational process in a more systematic and strategic way.

Companies active in battery manufacturing, quality control, diagnostics, and recycling, can contribute significantly by **offering internships, apprenticeships, and laboratory-based learning experiences**. These placements should be well-structured, with clear learning objectives, supervision from both company and

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academic mentors, and alignment with the curriculum. Access to industry-standard equipment—such as battery cyclers, thermal chambers, and battery management systems—can provide students with hands-on experience that many educational institutions are not yet equipped to offer internally.

In addition to hosting students, companies should also be actively involved in **co-designing training content**. A particularly effective way to achieve this is through the integration of real-world case studies into classroom activities. These can include examples of battery system failures and root-cause analysis, optimization of charging protocols, design of second-life applications, or sustainability challenges in sourcing raw materials. Such case studies allow students to apply theoretical knowledge in simulated but realistic settings, promoting problem-solving skills and a deeper understanding of industry dynamics.

These collaborations may take the form of memoranda of understanding with ITS Foundations, agreements with university departments, or participation in regional innovation clusters. Educational institutions should also be encouraged to invite industry professionals to participate in lectures, project reviews, and skills assessment sessions, thereby reinforcing the connection between classroom learning and workplace expectations.

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7. Conclusion

The analysis carried out in this report has highlighted several critical gaps in Italy's battery-related education and training landscape. These gaps affect three key dimensions:

- **Technical knowledge**, particularly in relation to battery chemistry, lifecycle management, safety, and emerging technologies such as solid-state batteries and AI-integrated systems;
- **Practical skills**, due to limited access to modern laboratories, equipment, and structured hands-on learning experiences;
- **Soft and transversal skills**, such as project management, interdisciplinary collaboration, and safety culture, which remain underdeveloped in many programs.

These weaknesses impact students, educators, and companies alike, and risk slowing down the development of a qualified workforce for one of Europe's most strategic technological sectors.

Recommendations

To respond to these gaps, the report has put forward a set of concrete and actionable recommendations. These include:

- The **modernization of curricula**, through the development of modular learning materials and practical manuals focused on battery fundamentals, safety, diagnostics, and circular economy principles;

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- The **training and upskilling of educators and professionals**, through short-term, hands-on certification programs, train-the-trainer workshops, and access to shared innovation labs;
- The **reinforcement of industry collaboration**, with companies contributing to curriculum co-design, offering internships and apprenticeships, participating in classroom activities, and co-developing real-world case studies.

These recommendations aim to create a more coherent, flexible, and responsive training system capable of meeting current and future demands in the battery sector.

Next steps

The next phase involves the **pilot implementation of the proposed interventions** at the regional and institutional levels. This includes:

- Launching collaborative curriculum development initiatives involving ITS, universities, and industrial partners;
- Establishing or upgrading battery labs and simulation tools within training centers;
- Activating structured agreements with companies for student placements and co-designed training modules.

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- INAPP Report 2023 – Work, Training, Welfare: an uneven path of growth. This report provides a detailed analysis of the transformations in the Italian labor market, with a particular focus on emerging skill needs and the challenges faced by the vocational training system. https://www.inapp.gov.it/en/publications/inapp-report/published-editions/inapp-report-2023
- Joint Note by ANPAL, Ministry of Labor and Bank of Italy – March 2023, "The Labor Market: Data and Analysis". This publication offers updated labor market data, highlighting employment trends and the demand for specific skill profiles.
- Excelsior Bulletin 2023 – Excelsior Information System (Unioncamere and ANPAL). This bulletin provides forecasts on labor demand and information on the difficulty in finding technical profiles, including those related to the battery supply chain.
- INAPP Report 2024 – Work and Training: a necessary paradigm shift. This report analyzes labor market trends and the effectiveness of active labor market policies and training, with a focus on lifelong learning and innovative strategies to support job transitions.
- ANPAL Servizi Report 2022 – Advanced Apprenticeships and Research in ITS Programs. This report presents an overview of advanced apprenticeship contracts implemented within the ITS system, offering data and insights on contracts activated between 2018 and 2022.

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- Documentation provided by ECOLE's Italian network, which shared resources on ITS programs, company collaborations, and training initiatives in the fields of energy and sustainable mobility.

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BATPOWER: PREPARATION OF THE VET LEVEL ON BATTERY ENERGY

Identification of Gaps and Needs in Battery Energy Education in Slovakia

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Executive Summary

This analysis examines the current state of battery energy education within vocational education and training programs, identifying critical gaps and areas for improvement. As the battery sector expands rapidly due to increasing demand for energy storage, electric vehicles, and renewable energy solutions, ensuring a skilled workforce is essential. However, VET institutions currently lack specialized curricula covering battery chemistry, lifecycle management, recycling, and safety protocols. Additionally, practical training opportunities, such as internships and industry collaborations, remain insufficient, limiting students' ability to gain hands-on experience with battery technologies.

To bridge these gaps, this study recommends a multi-faceted approach focusing on three key areas: curriculum development, educator training, and industry collaboration. VET institutions should implement structured educational materials, interactive learning tools, and certification programs to provide students with industry-relevant knowledge and skills. Train-the-trainer programs will ensure educators are equipped with the latest advancements in battery manufacturing, testing, and energy storage solutions. Strengthening partnerships with battery manufacturers, energy companies, and research institutions will facilitate internships, apprenticeships, and real-world training opportunities, allowing students to apply their knowledge in practical settings.

By implementing these targeted interventions, the battery workforce can be better prepared to meet industry demands, ensuring that Europe remains at the forefront of innovation and sustainability in battery energy storage. This analysis underscores the urgent need for structured educational reform in the VET sector to support the growth of a skilled, future-ready workforce capable of driving the global energy transition.

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Introduction

Battery energy technologies are vital for achieving the European Green Deal's goals and transitioning to sustainable energy. As demand for clean energy grows, batteries play a key role in energy storage, electric mobility, and grid stability. To support this, the European Commission has introduced legislation promoting sustainable and circular battery production, reducing environmental impact, and enhancing Europe's industrial competitiveness. The new regulations set stricter standards for battery design, recycling, and material sourcing, aligning with the EU's climate neutrality targets. By encouraging responsible supply chains and sustainable raw material use, the EU aims to reduce reliance on non-renewable resources while fostering innovation in battery technology.

Beyond environmental and industrial aspects, the policy also emphasizes workforce development. The battery sector requires skilled professionals in battery chemistry, lifecycle management, and energy storage. Aligning vocational education and training with industry needs is essential for preparing a future-ready workforce, ensuring Europe remains a leader in battery innovation and sustainable energy.[1]

Challenges in Battery Industry Education and Training

Current vocational education and higher education programs are not fully aligned with the evolving needs of the battery industry. As battery technology advances, the demand for skilled professionals in energy storage, electric mobility, and sustainable infrastructure grows. However, many training programs lag behind industry developments, leading to a mismatch between graduates' skills and employer expectations.

The Battery Industry Education and Training Needs Assessment (BIETNA) study identifies significant skill gaps, particularly in battery chemistry, lifecycle management, advanced manufacturing, and recycling. Without targeted improvements, these gaps may slow down industry growth and the transition to a sustainable energy future. To address these challenges, education providers must collaborate with industry to develop specialized training, practical learning experiences, and certifications. Hands-on apprenticeships,

[1] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7588

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internships, and upskilling programs are essential to ensure a workforce that meets industry demands. Aligning education with these needs will strengthen Europe's leadership in battery innovation and sustainable energy solutions.[2]

Addressing Workforce Gaps in the Battery Sector

The goal is to identify skill gaps and propose solutions to enhance workforce readiness in the battery industry. The *Battery Industry Education and Training Needs Assessment (BIETNA)* report analyzes current and future workforce needs, highlighting shortages in battery chemistry, management systems, and advanced manufacturing.

Key recommendations include:

- **Developing specialized training programs** to equip workers with essential skills.
- **Strengthening industry-academic collaboration** to align education with industry needs.
- **Expanding apprenticeships and certifications** for hands-on training.[3]

[2] https://www.cargroup.org/wp-content/uploads/2024/02/CAR_BIETNA_2024_PreblicationCopy.pdf

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Methodology

In developing the methodology for this study, we utilized a combination of desk research, partner contributions, and direct stakeholder engagement to comprehensively assess educational gaps in the battery sector across Slovakia, Italy, Hungary, and Spain.

Sources of Data:

- **Desk Research:** We conducted an extensive review of existing literature, industry reports, and academic publications to gather foundational data on the current state of battery industry education and workforce needs.
- **Analysis of Partners' Contributions:** Collaborations with partners such as DSA, ECOLE, and SGS TECNOS provided valuable insights and data specific to their regions and areas of expertise.
- **Surveys and Interviews with Stakeholders:** To gain firsthand perspectives, we conducted surveys and interviews with key stakeholders, including industry professionals, educators, and policymakers, to identify specific educational gaps and workforce requirements.

Focus Areas:

- **Technical Knowledge:** Assessing the current curriculum and training programs to determine deficiencies in technical subjects relevant to the battery industry.
- Practical Skills: Evaluating the availability and effectiveness of hands-on training opportunities, such as laboratory work, internships, and apprenticeships, that equip students with real-world experience.
- **Soft Skills:** Identifying gaps in essential soft skills, including project management, teamwork, and adaptability to new technologies, which are crucial for career success in the battery sector.
- **Educational Gaps in Partner Regions:** Focusing on Slovakia, Italy and Spain, we examined regional disparities in educational offerings and alignment with industry needs. For instance, a report highlighted that Slovakia's battery industry is hindered by a shortage of startups and

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innovative ventures, indicating potential gaps in entrepreneurial education and support. [4]

This multifaceted approach ensured a comprehensive understanding of the educational landscape and informed the development of targeted recommendations to bridge identified gaps.

[4] https://pspa.com.pl/wp-content/uploads/2023/05/PSPA_Europe_Runs_on_Polish_Li-Ion_Batteries_Report_EN.pdf

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1. Review of Current Programs and Gaps

1.1 Key Educational Gaps

The battery industry's rapid growth has highlighted significant educational gaps that need to be addressed to ensure a skilled and competent workforce. These gaps can be categorized into three main areas:

1. Technical Knowledge:

Limited Focus on Battery Chemistry, Safety Protocols, and Lifecycle Management:

Many current educational programs lack comprehensive coverage of essential topics such as electrochemistry, battery management systems, and safety protocols. The Battery Industry Education and Training Needs Assessment (BIETNA) report highlights substantial skill gaps in these areas, emphasizing the need for enhanced curricula to prepare students adequately. Without proper education on battery degradation processes, thermal runaway risks, and energy storage efficiency, graduates enter the workforce underprepared for industry demands. This deficiency not only affects individual career readiness but also impacts safety compliance and overall industry performance.

Lack of Advanced Modules on Recycling, Disposal, and Sustainability:

There is a significant gap in educational content covering battery recycling, disposal, and sustainability, which are crucial for the industry's transition to a circular economy. Initiatives like BATTERY 2030+ aim to bridge this gap by enhancing information exchange and education across Europe. Their goal is to provide students with an overview of available educational pathways in the battery sector and to compile resources on training programs, workshops, and sustainability-focused courses. Expanding such initiatives is essential to preparing a workforce capable of supporting sustainable battery management and innovation.[5]

2. Practical Skills:

[5] https://battery2030.eu/education/

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Insufficient Hands-On Experience with Modern Tools:

Many students lack access to modern battery testing equipment, real-time diagnostics tools, and simulation software, which are crucial for hands-on learning. The BIETNA report reveals that while theoretical knowledge is widely taught, practical applications are often missing from educational curricula. Unlike other advanced manufacturing sectors, the battery industry offers limited apprenticeship opportunities, restricting students from gaining essential hands-on experience. In some regions, battery testing labs are only available in private companies, making it difficult for educational institutions to provide adequate training. Without direct experience in working with batteries, graduates face challenges in adapting to real-world industry requirements.

Few Opportunities for Internships and Real-World Exposure:

The NAATBatt Education Committee Survey indicates that a lack of structured internship programs is a major barrier to workforce development in the battery industry. Most training programs fail to integrate industry-based learning, leaving students with limited exposure to industrial-scale battery production and maintenance. More than 75% of surveyed battery manufacturers reported difficulty in finding graduates with practical experience, highlighting the need for stronger collaboration between education providers and industry. Furthermore, short-term vocational training for mid-career workers is insufficient, making it difficult for existing professionals to upskill in new battery technologies. Addressing this gap through enhanced internship opportunities and workforce development programs is crucial to meeting industry needs.[6]

3. Soft Skills:

Lack of Training in Project Management, Collaboration, and Adaptation to Green Technologies:

Soft skills such as project management, teamwork, and adaptability to new, environmentally friendly technologies are often overlooked in battery-related education. The BIETNA report identifies that many professionals struggle with cross-functional collaboration, particularly when integrating battery technologies into larger energy systems. Training programs rarely include

[6] https://nac.naatbatt.org/wp-content/uploads/2022/12/NAATBatt-Edu-Comm-Survey-Results-Overview_Final_Dec-21-2021.pdf

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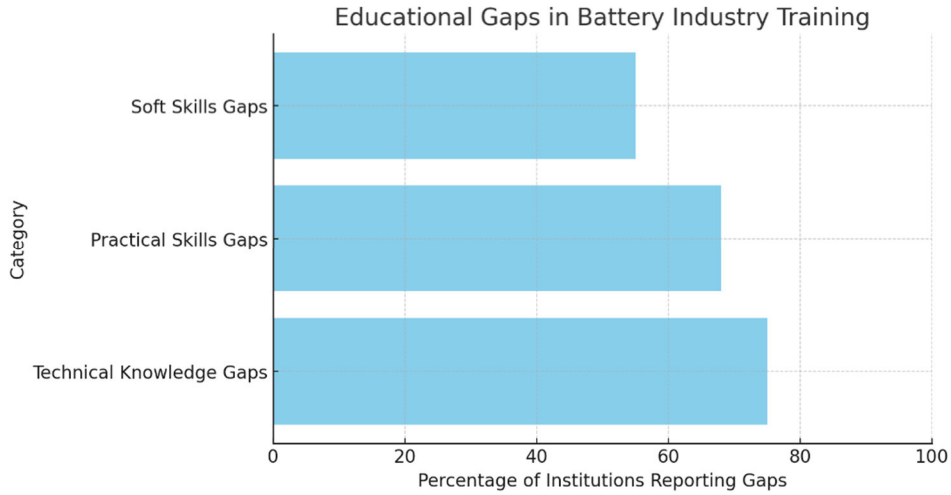
project management methodologies specific to battery production, deployment, and recycling, leaving professionals unprepared for leadership roles. Additionally, a shortage of professionals skilled in interdisciplinary teamwork presents a challenge in integrating battery storage solutions with renewable energy grids. Addressing this gap requires a greater emphasis on soft skills training within technical education to prepare graduates for the evolving demands of the industry.



1.3 Regional Challenges

The integration of battery technologies into educational systems varies significantly across Europe, with some regions advancing rapidly while others maintain more traditional approaches. These disparities impact workforce readiness, innovation potential, and the ability of different countries to meet the growing industry demand for skilled professionals.

Varying Levels of Integration Across Europe

While some countries have introduced specialized battery-related curricula, others lack structured programs to support industry growth. The **European Battery Alliance Academy** was launched to address these gaps, providing a coordinated approach to reskilling and upskilling workers across EU member states. This initiative focuses on establishing high-quality training programs that align with the evolving needs of the battery sector, ensuring that Europe

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remains competitive in the global market. However, challenges remain in fully integrating these programs into national education frameworks.[7]

Case Study: Slovakia's Growth with InoBat Initiatives

Slovakia stands out as a country making significant strides in battery technology education through initiatives led by **InoBat**, a leader in battery innovation. Despite the country's emerging status as a key player in the battery industry, Slovakia has historically lacked comprehensive educational programs in electromobility and battery business fields. Recognizing this gap, InoBat has launched several initiatives to support education and workforce development, including:

- **Academic Collaborations:** Partnering with universities and technical schools to develop specialized curricula.
- **Student Programs:** Offering internship and shadowing opportunities to provide hands-on industry experience.
- **Training for Professionals:** Creating targeted programs to reskill and upskill workers for the evolving battery sector.

These efforts are helping Slovakia transition from traditional educational approaches to a more industry-driven model, aligning with European trends and supporting the growth of its battery sector.[8]

[7] https://employment-social-affairs.ec.europa.eu/news/new-european-battery-academy-launched-boost-skills-fast-growing-battery-ecosystem-europe-2022-02-23_en
[8] https://www.inobat.eu/slovakia-lacks-comprehensive-education-in-the-electromobility-and-battery-business-fields-when-will-change-take-place

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2. Identification of Needs

2.1 Needs of Students

Access to Updated, Practical Learning Tools

Many training programs lack hands-on learning, limiting students' ability to work with real-world battery systems. The BIETNA report highlights gaps in battery diagnostics, testing, and validation training, underscoring the need for improved practical education.

To bridge this gap, institutions are integrating interactive training systems. The High Voltage Battery Training System offers realistic hands-on experience in EV battery management, using real-world components to prepare students for industry demands.[9]

The U.S. Department of Energy's Battery Workforce Challenge Program further enhances practical training by establishing regional workforce hubs to train students and reskill workers for high-demand jobs in battery manufacturing and EV technology.[10]

2.2 Needs of Educators

Upskilling Programs on Emerging Battery Energy Topics

To address the evolving landscape of battery technology, educators need comprehensive training in areas such as safety protocols, lifecycle management, and recycling processes. The U.S. Department of Energy's Battery Workforce Challenge Program is a notable initiative in this regard. Managed by Argonne National Laboratory, the program establishes regional workforce training hubs aimed at filling critical skill gaps. These hubs focus on reskilling and upskilling vocational and transitional workers, including

[9] https://www.automotivetrainingequipment.com/blogs/news/high-voltage-battery-training-system-for-electric-vehicle-education
[10] https://www.energy.gov/eere/articles/us-department-energy-kicks-nationwide-battery-workforce-challenge-program

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educators, to meet the demands of electric vehicle (EV) and battery manufacturing industries.[11]

Access to Modern Teaching Resources and Tools

Equipping educators with up-to-date teaching materials is essential for effective instruction in battery energy topics. The National Energy Education Development (NEED) Project offers a comprehensive suite of curriculum materials tailored for various educational levels. These resources cover a broad spectrum of energy concepts, including renewable energy and energy efficiency, providing educators with the tools needed to deliver engaging and informative lessons. [12]

Additionally, the Clean Energy Institute provides STEM-based curricula aligned with state science standards. This program offers exciting and engaging energy-related content, assisting educators in bringing contemporary energy topics into the classroom. [13]

By participating in specialized upskilling programs and utilizing modern teaching resources, educators can enhance their instructional capabilities, ensuring that students are well-prepared to meet the challenges of the rapidly evolving battery energy sector.

2.3 Industry Needs

The battery industry is experiencing rapid growth, leading to a heightened demand for skilled professionals proficient in battery assembly, testing, and management systems. To meet this demand, there is a pressing need for short-term training programs aimed at upskilling the current workforce.

Industry Demand for Skilled Professionals

A comprehensive study by the Center for Automotive Research (CAR) highlights significant skills gaps in the North American battery industry. The

[11] https://www.energy.gov/energysaver/energy-resources-educators
[12] https://www.need.org/about-need/our-curriculum
[13] https://www.cei.washington.edu/lesson-plans-resources/at-home-learning-resources

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report identifies critical shortages in areas such as electrochemistry, battery chemistry, battery management systems, product and system design, manufacturing, and safety. These deficiencies underscore the industry's need for professionals adept in battery assembly, testing, and management systems. [14]

Further emphasizing this point, a report from *Battery Technology Online* notes that industry-wide, the most substantial skills gaps are in electrochemistry, battery chemistry, battery management systems, product and system design, manufacturing, and safety. This analysis indicates a widespread need for expertise in these critical areas to support the industry's expansion. [15]

European Initiatives for Battery Workforce Development

Recognizing the need for workforce upskilling in **battery technology**, several European initiatives have been introduced:

- **European Battery Alliance (EBA) Academy** – This program aims to train and upskill 800,000 workers by 2025, equipping them with the necessary expertise in battery production, testing, and recycling. The academy works with industry partners to ensure its curriculum meets the evolving demands of the European battery sector. [16]
- **Fraunhofer IFAM's Battery Training Program** – A comprehensive modular training program covering:
    - **Battery Cosmos** – Global battery market dynamics.
    - **Battery Data** – Digitalization in the battery industry.
    - **Battery Materials** – Key materials for performance and cost-efficiency.
    - **Cell Manufacturing** – Process steps in battery production.

[14] https://www.cargroup.org/bietna
[15] https://www.batterytechonline.com/design-manufacturing/report-battery-industry-needs-more-workers-with-higher-skills
[16] https://eit.europa.eu/news-events/news/european-institute-innovation-and-technologys-european-battery-alliance-academy

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- **Dismantling & Recycling** – End-of-life aspects of batteries. This program integrates microlearning techniques and allows self-paced learning.[17]

- **InnoEnergy Skills Institute –** A customizable battery training platform, collaborating with over 40 industry partners and having already trained 89,000 workers in battery production, testing, and sustainability.[18]
- **Northvolt's Battery Excellence Program –** A 12-18 month paid workforce development program, where participants train at Northvolt's gigafactories in Sweden and Germany, working directly with industry experts. The program offers hands-on learning, mentorship, and a guaranteed role in battery manufacturing upon completion.[19]

[17] https://www.qualifizierung.ifam.fraunhofer.de/en/battery-training.html
[18] https://www.innoenergy.com/skillsinstitute
[19] https://northvolt.com/c/career/battery-excellence-program

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3. Recommendations for Interventions

To address existing gaps in battery energy education, targeted interventions should focus on curriculum development, teacher training, and industry collaboration. By implementing structured educational materials, hands-on training programs, and stronger partnerships with businesses, vocational education and training institutions can better prepare students for careers in the rapidly evolving battery sector.

1. Development of Educational Materials

Curriculum and Training Modules on Battery Technologies

VET institutions should develop structured curricula covering battery chemistry, lifecycle management, safety protocols, recycling, and energy storage applications. These materials should provide both theoretical foundations and practical insights, ensuring students acquire industry-relevant knowledge. Introducing micro-credentialing programs and stackable certification courses would allow learners to build their expertise progressively and align with evolving industry requirements.

Practical Manuals and Interactive Learning Tools

To enhance hands-on learning, educational institutions should integrate interactive digital tools, simulations, and practical manuals into battery-related training. These tools should provide real-world applications of battery technology, including case studies, virtual labs, and problem-solving exercises that prepare students for industry challenges.

2. Training Programs

Workshops for Teachers (Train-the-Trainer Programs)

Educators play a crucial role in delivering up-to-date knowledge on battery technologies. Establishing train-the-trainer programs would ensure that VET teachers stay updated with industry advancements and gain the skills

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necessary to teach battery production, testing, and management. These workshops should include technical training, instructional strategies, and access to industry-standard tools, allowing educators to transfer practical knowledge effectively.

Short-Term Certification Courses for Students and Professionals

To meet workforce demands, VET institutions should develop short-term training programs that provide targeted battery-related skills. These courses should cover battery manufacturing, testing, safety compliance, and sustainable disposal practices. The inclusion of flexible learning options, such as online modules and hybrid learning, would enable both students and professionals to upskill efficiently and transition into high-demand battery industry roles.

3. Industry Collaboration

Stronger Partnerships with Battery Manufacturers and Energy Companies

Collaborating with businesses in the battery sector is essential for bridging the gap between education and employment. VET schools should establish long-term partnerships with battery manufacturers, electric vehicle producers, and energy storage companies to provide students with internships, apprenticeships, and real-world lab experiences. These collaborations would help students gain hands-on exposure to battery technologies, assembly processes, and safety protocols.

Integration of Industry Case Studies into Curricula

Bringing real-world case studies into VET curricula can enhance students' understanding of current industry trends and challenges. Incorporating problem-solving exercises, project-based learning, and analysis of existing battery innovations would help students develop critical thinking and applied skills needed in the workforce. Industry experts should also be invited to guest lectures, panel discussions, and mentorship programs, fostering deeper engagement between education and industry.

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Conclusion

The findings of this study highlight critical gaps in technical knowledge, practical skills, and industry collaboration within battery energy education. Current VET programs often lack structured training in battery chemistry, lifecycle management, recycling, and safety protocols, creating a disconnect between educational curricula and the evolving needs of the battery sector. Furthermore, practical training opportunities, such as internships and laboratory experience, remain limited, preventing students from acquiring essential hands-on experience with battery technologies. Additionally, soft skills, including project management and collaboration in green technologies, are often underdeveloped, further impacting workforce readiness.

To address these challenges, a comprehensive and targeted approach is necessary. The development of specialized educational materials and structured curricula will ensure that students gain a strong foundation in battery technology and its applications. Upskilling educators through train-the-trainer programs will enhance teaching effectiveness, ensuring that knowledge transfer remains aligned with industry advancements. Strengthening industry collaboration by facilitating internships, apprenticeships, and real-world training experiences will provide students with direct exposure to battery manufacturing, testing, and energy storage solutions. Additionally, expanding short-term certification programs and micro-credentialing opportunities will allow both students and professionals to continuously upskill and adapt to industry needs.

Moving forward, implementing these interventions will be crucial in bridging the existing gaps and ensuring that VET institutions prepare students for careers in battery energy storage, manufacturing, and sustainability. By aligning vocational education with industry demands, integrating hands-on training, and fostering collaboration between education providers and businesses, the European battery sector can develop a future-ready workforce capable of supporting innovation and driving the transition toward a sustainable energy future.

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