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Upskilling for the Future: The Role of Qualification in the Regional Transformation of the Automotive Industry in Baden-Württemberg

Lena Mueller, Saskia Schuettke
e-mobil BW GmbH
State Agency for New Mobility Solutions and Automotive Baden-Württemberg,
Leuschnerstrasse 45, 70176 Stuttgart, GERMANY,
lena.mueller@e-mobilbw.de

Executive Summary

The automotive industry is undergoing a fundamental transformation driven by technological change, climate policies and global market shifts. This paper explores the role of qualification as a key factor in managing this transformation, with a particular focus on small and medium-sized enterprises in Baden-Württemberg's automotive industry. Drawing on empirical insights from initiatives such as the Strategic Dialogue for the Automotive Sector BW, the funded project QualiBattBW as well as the EU project Voltage, the paper investigates how qualification measures can support companies in overcoming skills gaps and managing structural change. Grounded in transformation theory and the concept of skills ecosystems, the analysis examines the interplay between regional and EU policy frameworks and networks and strategic skills initiatives. The paper concludes by discussing policy recommendations to strengthen the effect of skills initiatives in the context of structural change and highlights key success factors and transferable approaches.

Keywords: Education, skills and labour market, Public Policy & Promotion, Battery manufacturing, Social equity, International Networking

1 Introduction

The automotive industry is currently experiencing an unprecedented pressure to transform stemming from a multitude of challenges. The imposition of CO_2 limits and binding decarbonisation targets is compelling car manufacturers in the EU to make substantial technological shifts towards electrification [1]. Digitalisation and emerging technologies such as autonomous driving have disrupted traditional value chains and are increasing the pressure to transform [2]. In addition, the United States is pursuing a protectionist trade policy, reducing sales opportunities for EU manufacturers [3], and China is pushing ahead with electric mobility in terms of technology, sales figures and an industrial policy that strongly supports electric vehicles and battery production [4,5]. As a result, the automotive industry is confronted with a complex interplay of ecological, economic and technological challenges that extend beyond the sector itself.

The EU automotive ecosystem is characterised by long and complex supply chains dominated by a few enterprises that have become global players on the one hand, and a large number of smaller and locally based suppliers, retailers and after-sales product and service providers on the other hand [6]. It is mainly composed of small and medium-sized enterprises (SMEs), representing 99.7 % of the companies active in this ecosystem [7]. The automotive value chain is a pillar of the EU economy, accounting for 12.9 million direct and indirect jobs, a contribution of EUR 1 trillion to the EU's Gross Domestic Product (GDP) and almost one third of private sector R&D investment in the EU [6].

Simultaneously, the transport sector is one of the largest sources of greenhouse gas emissions in the EU (after manufacturing and electricity and gas supply), accounting for 16 % of EU CO_2 emissions in 2024 [8]. Road transport is the largest contributor to total transport emissions, accounting for 73.2 % of all EU transport GHG emissions in 2022 [9]. Electrified powertrain concepts have become increasingly important for the automotive industry, driven by EU fleet-wide CO_2 emission targets [10]. While a proposal from the European Commission on 1 April 2025, as part of the Industrial Action Plan for the automotive sector, seeks to ease this pressure by allowing car and van manufacturers to meet their CO_2 targets over a three-year average (2025-2027) rather than annually [10], the broader push towards zero-emission mobility remains strong. The EU's zero-emissions target for 2035 for new passenger cars and light commercial vehicles [10], the finite availability of fossil fuels and growing public environmental awareness all underline the urgency of the transition from combustion technologies to renewable alternatives – a shift that is essential not only for climate goals, but also for securing the economic prosperity of the EU and its citizens. This transformation process necessarily affects the overall automotive sector, which is central in terms of its contribution to GDP and employment levels, and has significant interconnections with other sectors [11].

For automotive regions such as Baden-Württemberg, the transformation is not only technological but deeply structural, affecting employment, value chains, the regional economy and, not least, the cultural identity of the region. The automotive industry is one of Baden-Württemberg's core industries, with an annual turnover of just over EUR 135 billion [12]. Including related sectors and services, such as the motor vehicle retail, repair and aftermarket trades, the automotive cluster employs around 480,000 people, accounting for around one tenth of all jobs subject to social security contributions in Baden-Württemberg [12]. Following the region's path towards climate neutrality by 2040, five years earlier than the federal government and ten years earlier than the EU, automotive companies in the region play a central role in achieving the targets for the transport sector set out in the state government's Mobility and Climate Concept [13]. For SMEs with fewer than 250 employees, which represent 99 % of the 500,000 companies in Baden-Württemberg [14], the transition to electric mobility is particularly critical, as they typically produce a limited range of components and serve fewer products and industries, making them particularly vulnerable to structural change.

The drivetrain of electric vehicles is much simpler than that of internal combustion engine cars, which significantly reduces the number and complexity of assembly steps in the engine compartment and drivetrain [15]. However, the skills gained from working on internal combustion engines are not sufficient to work on electric vehicles, and workers will need to be retrained. Even if all fade-in effects for electromobility and automated driving are fully realised in Baden-Württemberg, the core of the automotive cluster will still experience a loss of 29,300 jobs (in the "business-as-usual" scenario) or 42,700 jobs (in the "progressive" scenario) by 2030 [16]. These alone would lead to an overall decline in employment of 6 % and 9 % in the entire cluster [16]. While some of this decline will be offset by demographic change and the associated reduction in the labour force, some of the current jobs will have to be shifted to other sectors. Nevertheless, a large proportion of the current automotive workforce in the region can be retained through targeted upskilling. More than 30,000 workers will need to be trained in new technologies over the next ten to fifteen years [16]. In addition, the integration of new components such as batteries will allow new players to enter the market and create new jobs along the supply chains [1]. Battery technology is emerging as an area of high strategic importance. Companies with a strong presence in the battery value chain gain a competitive advantage in the automotive electrification [17].

As firms seek to adapt their business models and technologies, the availability of skilled labour and the ability to upskill existing workers become central to regional resilience. Empirical evidence shows that regions most affected by job losses due to structural change – often referred to as those 'left behind' – experience declining prosperity, reduced life expectancy and a rise in populist sentiment. This, in turn, fuels resistance to decarbonisation targets and wider transformation efforts [18].

This paper examines how qualification measures can support companies in overcoming skills gaps and managing the transformation of the automotive industry, with a particular focus on how targeted initiatives support SMEs in Baden-Württemberg in adapting to structural change. Drawing on empirical evidence from Baden-Württemberg's regional programmes – the Strategic Dialogue for the Automotive Sector BW and the funded project QualiBattBW – as well as the EU project Voltage and European networks, this paper explores the hypothesis that qualification becomes a key factor in the successful transformation of the automotive industry when it enables firms to close skills gaps and respond effectively to changing market demands.

Drawing on transformation theory and the theoretical context of skills ecosystems, the paper situates these regional policies within broader European debates on industrial competitiveness, upskilling and employment security in the context of increasing pressure from non-European markets such as China, and analyses how regional action can contribute to European strategies. The analysis proceeds in three steps: it first outlines the theoretical and policy context, then presents findings from the regional case of Baden-Württemberg embedded in the European context and discusses implications for future qualification strategies.

2 Theoretical Framework: Transformation Theory and Skills Ecosystems

The transformation of the automotive industry is not merely a technological shift, but a deeply structural one. To better understand how qualification can act as a driver of transformation in the automotive sector, the following section outlines the theoretical foundations, focusing on transformation theory and the concept of skills ecosystems as lenses for analysing regional change dynamics. Together, these perspectives allow an analysis of the drivers of change and the mechanisms through which regions can build adaptive capacity – particularly SMEs, which often struggle to access the resources and infrastructure needed to manage major transitions.

2.1 Transformation Theory: Understanding Structural Change

Transformation theory provides a macro-structural understanding of how industries, technologies and institutions undergo fundamental change. Rather than focusing on linear or incremental development, this body of theory emphasises disruptive shifts that require actors to reconfigure established practices, knowledge bases and value networks [19,20]. Geels (2002) defines Technological Transitions (TT) as '[…] major technological transformations in the way societal functions such as transportation, communication, housing, feeding, are fulfilled. TT do not only involve technological changes, but also changes in elements such as user practices, regulation, industrial networks, infrastructure, and symbolic meaning' [19]. The resulting socio-technical configurations make it difficult for new technologies to break through '[…] because regulations, infrastructure, user practices, maintenance networks are aligned to the existing technology' [19]. However, socio-technical configurations do not remain closed [19]. Rotmans et al. (2001) introduce the element of government policy, which can influence, but never fully control, the direction, scale and speed of possible development paths that transitions entail [20].

Such transformations are often multi-causal, driven by interacting forces such as technological innovation, regulation, consumer behaviour and global economic dynamics. In the case of the automotive industry, external pressures – ranging from EU emissions regulations and electrification mandates to China's rapid advances in electric vehicle and battery production – combine with internal dynamics such as shrinking supplier markets and labour shortages to create high transformation pressures. For SMEs in particular, the ability to respond to these pressures is shaped by their organisational 'change readiness' – a concept that includes openness to innovation, investment in workforce development and the strategic alignment of skills with future needs [21]. Often cited as having limited time, human and financial resources to upskill their workforce [22], SMEs have a lower adaptive capacity and are therefore particularly vulnerable during transformation. However, transformation theory also recognises that agency alone is not enough. Regional and institutional contexts play a crucial role in enabling or constraining adaptive responses. This is where the skills ecosystem perspective offers additional explanatory power.

2.2 Skills Ecosystems: A Systemic View of Workforce Development

The concept of skills ecosystems shifts the analytical focus to the meso-level – the network of interdependent actors that co-produce, distribute and maintain skills in a given region or sector [23]. So-called 'high-skill

ecosystems' (HSEs) are defined as '[…] a geographic cluster of organizations (both firms and research institutions) employing staff with advanced, specialised skills in a particular industry and/or technology' [23]. Once established, HSEs '[…] generate a positive, mutually reinforcing dynamic that fuels ongoing knowledge creation and growth and adaptation to changing competitive conditions' [23]. The approach promotes the essential role that forums for cooperation between enterprises, research institutes, social partners and education and training providers in a region can play in the development of HSEs. This is particularly the case when they support the pooling of public and private investment in infrastructure, training and applied research, and facilitate the exchange of knowledge and the creation of individual networks that increase the rate of innovation within the area [23]. However, HSEs tend to focus on generating growth in high-wage jobs, so there is a need to further explore the value of skills ecosystems in the transformation of the automotive industry, which includes many low- to medium-skilled jobs.

These ecosystems typically include enterprises, vocational education and training providers, chambers of commerce, trade unions, employment agencies and government actors. Rather than viewing skills development as a one-way process from education to employment, skills ecosystems emphasise the co-evolution of skills supply and demand. This co-evolution is particularly important in sectors undergoing transformation, where existing skills may no longer match new technological and organisational realities.

A key lesson from research on skills ecosystems is that coordinated action – rather than isolated initiatives at the firm level – is essential for systemic resilience. This is particularly true for SMEs, which, unlike large firms, often lack the internal resources to identify, design, and implement comprehensive upskilling strategies on their own. In such contexts, collective infrastructures such as regional qualification initiatives, innovation hubs and sectoral networks become crucial enablers. These infrastructures not only pool resources and reduce transaction costs, but also promote joint problem definition and mutual learning.

Integrating transformation theory and skills ecosystems thus allows for a more holistic understanding of workforce qualification in the context of industrial change. While transformation theory explains the urgency and depth of change – rooted in macroeconomic and technological trends – skills ecosystem theory shows how regional structures can either enable or inhibit firms and workers to respond effectively. Moreover, this combined lens makes visible the feedback loops between policy, institutional capacity and firm-level behaviour. It also aligns with recent EU policy calls to strengthen place-based innovation ecosystems and regional resilience, as articulated in strategies such as the Green Deal Industrial Plan [24] and the European Skills Agenda [25].

In the remainder of the paper, this dual framework will guide the analysis of how qualification strategies in Baden-Württemberg support SMEs in adapting to transformation pressures. It will also help to identify critical bottlenecks – such as limited institutional coordination or gaps in continuing education provision – that could impede the development of a robust, future-ready skills ecosystem.

3 Methodology

This paper uses a qualitative, case-based approach to explore how qualification can function as a strategic lever in the regional transformation of the automotive industry. The empirical focus lies on Baden-Württemberg, a key automotive region in southern Germany undergoing a major structural transformation due to decarbonisation, digitalisation and global market dynamics. Given the complexity of this transformation and the diversity of actors involved, the study draws on a mix of policy analysis, survey data and project documentation to examine the role of qualification initiatives in supporting SMEs in particular.

The analysis is based on two regional initiatives: the Strategic Dialogue for the Automotive Sector BW and the project QualiBattBW. Both serve as representative examples of collective infrastructures aimed at enabling a successful transformation. While the Strategic Dialogue provides the overarching policy and governance framework, QualiBattBW functions as a targeted upskilling initiative focused on battery related skills, thus addressing a concrete emerging qualification need within the broader ecosystem.

For the Strategic Dialogue, this paper draws on policy documents, including a policy paper outlining the dialogue's objectives, structure and governance model [26]. The Strategic Dialogue brings together numerous stakeholders from politics, business, industry, science, academia, unions, associations and civil society to

address the diverse and complex challenges arising from climate goals, technological innovations, social changes and the ongoing transformation of the automotive industry including all related sectors of the economy. This multi-stakeholder format illustrates the institutional dimension of the regional skills ecosystem and reflects an explicit effort to strengthen coordination mechanisms between the public and private sectors.

The empirical basis for the QualiBattBW case includes both internal project data and stakeholder engagement processes. At the outset of the project, a needs assessment was conducted in the form of an online survey circulated among 70 SMEs from the automotive industry (June–July 2023) to gather information on current qualification needs, perceived skills gaps and expected future demands, with a particular focus on SMEs. The results were subsequently discussed and refined in two moderated in-depth workshops with 20 participants per workshop from almost the entire battery ecosystem in Baden-Württemberg. In addition to this exploratory needs assessment, the project provides operational data on the uptake and implementation of the programme. This includes registration numbers, participant profiles (e.g. professional background, company size and type) and evaluation data from feedback forms. This dataset allows an assessment of the reach, relevance and perceived effectiveness of the programme.

By combining data from a concrete qualification initiative with the broader strategic governance framework, the methodology allows for a multi-layered understanding of how regional skills ecosystems operate in practice. It enables the analysis of both micro-level interactions (e.g. participation patterns and learning feedback) and meso-level institutional structures (e.g. policy coordination and ecosystem resilience). This triangulated approach is particularly suited to the study of transformation processes, where systemic change requires alignment across multiple levels and actors.

4 Baden-Württemberg as a Transformation Case

Baden-Württemberg is one of Europe's leading automotive regions, home to global original equipment manufacturers (OEMs) such as Mercedes-Benz and Porsche, as well as a dense network of suppliers and research institutes [12]. The sector is therefore deeply embedded in regional value creation. The transformation of the automotive cluster towards electric mobility requires high levels of investment and additional industrial space for the production of new components and systems. This is particularly challenging in the region due to the limited availability of land, a disadvantage highlighted in studies involving companies such as Northvolt and Cellcentric [12]. Reluctance to invest in German locations due to high labour and energy costs, the entry of new international competitors and Germany's comparatively low EV sales (2024: 0.57 million EVs) further exacerbate the situation – especially when compared to global leaders such as China (2024: 7.98 million EVs) [27].

The employment effects associated with the phasing out of the internal combustion engine (ICE) (fade-out) and the market ramp-up of components for electric mobility and automated driving (fade-in) will have a significant impact on the entire automotive cluster in Baden-Württemberg. By 2040, the employment effect of the complete phase-out of the ICE will be more than -30 %, or around 154,500 jobs [12]. At the same time, new roles are emerging in battery production, software development and data-driven services – creating a mismatch between existing competencies and future skill requirements. This presents a twofold challenge: reorienting the existing workforce through upskilling and reskilling, while simultaneously safeguarding current value creation by ensuring access to a highly skilled, specialised workforce.

The automotive cluster in Baden-Württemberg is characterised by close links between industry, service providers and associated research institutes [12]. To adapt to new powertrain technologies, these institutions will need to expand their capabilities in areas such as battery cell manufacturing, semiconductor production and software development. If equipped with the appropriate qualification measures to develop the required skills, Baden-Württemberg has the opportunity to leverage its strengths, including a highly qualified and skilled workforce, leading universities and research institutes, and a strong industrial base [12].

In response, e-mobil BW, the State Agency for New Mobility Solutions and Automotive Baden-Württemberg, has launched advisory formats and cooperation projects aimed specifically at supporting SMEs in their transformation. As part of the Strategic Dialogue for the Automotive Sector BW, the 'Dialog format for transfer qualification and readiness for change' and the mission 'Skilled workers for the BW automotive industry: qualifying and recruiting young trainees' were established to address the qualification and workforce

challenges posed by the transition to electromobility. The project QualiBattBW, led by e-mobil BW and funded by the Federal Ministry for Economic Affairs and Climate Action, supports workforce development along the battery value chain by offering free training modules. At European level, the Voltage project aims to strengthen the capacity of vocational education providers in the battery sector. All activities are embedded in European networks to share best practices and support knowledge transfer between regions.

4.1 Strategic Dialogue for the Automotive Sector BW: Coordinated State-Industry Action

With the Strategic Dialogue for the Automotive Sector BW (SDA), the state government of Baden-Württemberg has established a new cross-topic and cross-sectoral working format, in which stakeholders from politics, business, science, employee associations and civil society work closely together to proactively meet the challenges of the automotive industry in the current structural change [26]. Since 2017, the SDA has initiated a total of 70 projects, so-called 'missions', to drive the transformation process in the automotive industry [28].

Within this framework, the mission 'Dialog format for transfer qualification and readiness for change' was established to create an opportunity for the automotive industry to exchange business practices and ideas. Companies can share their experiences and discuss challenges, best practices and lessons learned with regard to qualification concepts, changing job activities and improving employees' readiness for change [29]. The dialog format aims to enable SMEs to initiate transformation processes with their existing workforce, to maintain and develop their skills and to promote readiness for change. The approach seeks to preserve industry-specific knowledge and build competencies to reduce transition risks for SMEs. The dialog format creates networking opportunities and promotes exchange between HR and training professionals as well as works council members from supplier and automotive companies.

The mission 'Skilled workers for the BW automotive industry: qualifying and recruiting young trainees' focuses on vocational training and discusses the challenge of fewer and less qualified applicants, especially for technical apprenticeships. In collaboration with social partners and industry stakeholders, the mission seeks to develop concrete recommendations for action and implementation. Key areas of focus include increasing transparency around training pathways and identifying factors that influence industry attractiveness and the quality of applications [30]. The missions in the SDA have been instrumental in bringing skills issues to the forefront of the state's political agenda, ensuring that workforce development remains a central concern in future policymaking. In line with transformation theory, these efforts acknowledge that systemic change in the automotive industry requires coordinated shifts in regulation, institutional practices and workforce development.

4.2 QualiBattBW: Workforce Upskilling for the Battery Value Chain

In Baden-Württemberg, the growing battery ecosystem requires a workforce with specialised skills to meet the needs of the industry. The project QualiBattBW, launched in April 2023, plays a crucial role in upskilling the regional workforce by developing and testing qualification modules across the entire battery value chain [31]. With a focus on SMEs, the project aims to strengthen the region's competitive position by ensuring a steady pipeline of skilled workers to meet the rapidly evolving needs of the sector. The project draws on the expertise of a broad consortium of research and education stakeholders, in addition to the Cluster Electric Mobility South-West as the project's consortium leader. This extensive and diverse network with a long-standing focus on the automotive industry, aims to enhance the quality and accessibility of training content for SMEs. The initiative comprises a total of 40 learning units, organised into 7 modules, which are offered free of charge and vary in format (online/in-person) and duration (half-day, full-day, two-day) [31].

Based on the skills gaps identified in a needs analysis with 70 SMEs from the automotive industry in Baden-Württemberg, training modules were developed in line with state-of-the-art research and established pedagogical approaches to create industry-demand driven, application-oriented learning units. The results highlighted a preference for online formats to deliver theoretical content, while complex or practical topics were better suited to in-person sessions. Importantly, the analysis also highlighted the need to offer different levels of theoretical depth to cater for the diverse professional backgrounds of learners – ranging from production workers to purchasers, engineers and managers.

These findings guided the development and pilot implementation of selected learning units in just six months, in response to the urgent industry demand. To date, the programme has received over 400 bookings from more than 100 companies, mainly automotive suppliers, battery manufacturers as well as machine and plant manufacturers. Since the start of the pilot phase in April 2024, 25 sessions have been held, reaching over 280 participants, mainly skilled workers and team or project leaders. In addition, companies have access to tailored consultancy services and training for internal learning facilitators to help them select the right learning units for their qualification needs. The future objectives of the project are twofold: firstly, to further evaluate the optimisation of the targeting strategy to effectively engage the group of production workers; and secondly, to increase the proportion of SMEs participating in the learning units in order to strengthen the region's industrial ecosystem as a whole.

4.3 Added Value of Regional Approaches and Bottlenecks

Regional approaches to skills development in the battery industry offer unique advantages, particularly in areas like Baden-Württemberg. By leveraging local clusters and networks such as the Cluster Electric Mobility South-West, regions can foster strong links between industry, research institutions and education providers. These partnerships are critical to addressing the specific skills needs of the local economy and ensuring that qualification efforts are directly aligned with the needs of the industry.

In Baden-Württemberg, regional initiatives such as QualiBattBW have proven effective in building a skills ecosystem of knowledge and expertise tailored to the needs of the battery sector. These localised efforts allow for a more flexible and targeted approach to workforce development. Moreover, regional approaches have the potential to enhance the responsiveness of training programmes by facilitating adaptation or scaling.

Despite the clear benefits of regional initiatives, several bottlenecks continue to hinder the successful scaling up of workforce development programmes for SMEs. A key challenge is the limited availability of time resources: many SMEs operate on rigid shift systems, making it difficult to release employees for external training without disrupting day-to-day operations. As a result, smaller firms often remain under-represented in upskilling programmes, leaving their workforce inadequately prepared for the demands of the sector transformation. Financial barriers also play a significant role, as many SMEs lack the capacity to invest in customised training solutions that often entail high initial costs. From a skills ecosystem perspective, collaborative approaches that pool resources and offer subsidised training modules can help overcome these constraints. By reducing cost and access barriers, such ecosystems enable smaller firms to benefit from quality learning opportunities and actively participate in sectoral transformation processes.

While successful pilot programmes and regional initiatives have demonstrated the potential of targeted skills interventions established in regional clusters and networks, scaling up these efforts to a broader scale requires careful coordination across institutions, including industry associations, research institutes and education providers. Achieving seamless alignment between these stakeholders through formats such as the Strategic Dialogue for the Automotive Sector BW is essential to develop standardised, scalable skills interventions that can be applied across different regions and sectors.

5 The European Context

In the European mobility sector, the dual transformation driven by digitalisation and electrification is reshaping the nature of work and collaboration. As highlighted in recent studies, these two forces are not acting in isolation but are mutually reinforcing, increasing the need for cross-functional and cross-organisational collaboration, networks and partnerships [32]. The EU remains one of the world's top three automotive markets, but its position is being challenged, particularly by China's assertive industrial strategy and leadership in battery technologies, EV production and related raw materials [33,4,17]. This competition is not only technological, but systemic – centred on access to raw materials, speed of innovation and new consumption patterns [5,34].

In response, the EU has launched several policy initiatives – including the Pact for Skills [25], the Green Deal Industrial Plan [24], the Net-Zero Industry Act [35] and most recently the Clean Industrial Deal [36] – to address skills gaps, strengthen regional supply chains and promote resilience. However, implementation challenges remain, particularly around battery manufacturing and technological sovereignty [37].

Clusters play a key role in this evolving landscape. Across Europe, they are emerging as critical actors in developing the skills needed for the future mobility ecosystem. By fostering collaboration between universities, training providers, social and industry partners, clusters are helping to expand and diversify the talent pool. They take the lead in designing industry-relevant training programmes and co-developing curricula. In doing so, they help to ensure that education and training systems are responsive to the rapidly changing industry needs. Baden-Württemberg, together with Auvergne Rhône-Alpes, Lombardy and Catalonia, is a founding member of the interregional network '4 Motors for Europe' [38]. In the network's working group 'Electric and Hydrogen Mobility', members exchange strategies and projects on future transport technologies and share information and best practices on the transformation of the automotive industry across European regions, including qualification and training. Through mutual learning and cross-border cooperation, the initiatives help to align vocational training systems, support SMEs and promote the diffusion of innovation across regions.

As such, the interplay between EU-level ambitions and territorially embedded actions becomes essential for a socially just and globally competitive transformation of the automotive industry. Taken together, these trends underline the importance of ecosystem approaches to workforce transformation – approaches that are based on European cooperation and that recognise the growing importance of networks, shared learning structures and the collective shaping of skills development.

5.1 Voltage: Centres of Vocational Excellence on a European Level

Given the nascent nature of the battery industry in Europe, there is an urgent need for qualified professionals. According to the European Battery Academy there is an estimated need for 800,000 skilled workers in the battery sector [39]. In order to meet the human resource needs of the industry and to ensure the high quality of vocational education and training (VET), current training concepts need to be strengthened through the targeted integration of specific content and to be holistically aligned with the needs of new job profiles [40]. In this context, initiatives such as Voltage play a crucial role in operationalising EU strategies.

At European level, the Erasmus+ project Voltage fosters the development of Centres of Vocational Excellence (CoVEs) to strengthen the capacity of VET providers in the battery sector. CoVEs are formed by networks of partners from research, industry and education that develop local skills ecosystems to provide high quality vocational skills [40]. The underlying idea of the Voltage project is that the upcoming demands of the labour market should be reflected not only in the environment of higher education but especially at the VET level. By fostering collaboration between Sweden, Finland, Germany, Portugal and Turkiye, the Voltage initiative seeks to establish a European framework for aligning educational programmes with the evolving skills needs of the sector and improving the quality of VET across Europe.

The emerging CoVEs network will act as a catalyst for the exchange of best practices, enabling VET providers to adapt their curricula to the specific needs of the battery value chain. In addition, this initiative will help ensure that vocational educators and trainers are equipped with the knowledge and resources they need to provide high-quality training to the next generation of skilled workers, as VET providers may themselves face skills gaps. For market-driven curricula, the links between the mobility ecosystem and educational institutions will be strengthened through webinars and roundtables bringing together experts from industry and education on topics such as industry attractiveness, skills gap analysis, innovative partnership models, working with micro-credentials or EU funding opportunities.

To address the growing labour shortage and the declining attractiveness of careers in the mobility sector, the project targets the attractiveness of the battery sector by producing video content aimed at young students at the transition from school to work. In line with transformation theory, which emphasises the need to reconfigure socio-technical systems – including user expectations and symbolic meanings – the project aims to reshape perceptions of the battery sector. It does so by promoting a mission-driven narrative that frames battery-related careers as future-proof, meaningful and aligned with the goals of a sustainable and green economy. The project also aims to tackle some stereotypes to increase the participation of women in the mobility ecosystem by launching 'Battery Camps for Girls', where female students meet industry role models and engage in hands-on projects with companies along the battery value chain.

6 Discussion

The case of Baden-Württemberg illustrates the centrality of workforce qualification in managing the transformation of the automotive sector – particularly for SMEs, which form the backbone of regional value creation but are under disproportionate pressure due to limited resources. Empirical findings reveal critical skills needs related to the transformation of value chains and underline the importance of close-knit networks and alignment of key stakeholders from politics, industry and research and education. However, bottlenecks remain: limited time and financial capacity constrain SME participation; a lack of alignment between European and regional strategies weakens the effectiveness and scalability of regional actions, especially compared to more centralised industrial governance strategies such as those pursued by China.

Nevertheless, effective practices for fostering change readiness are emerging. Anchored in transformation theory, the Strategic Dialogue for the Automotive Sector BW exemplifies how government-led policy formats can help reconfigure entrenched socio-technical systems by fostering cross-sectoral collaboration, supporting the diffusion of new practices and enabling workforce-centred pathways for structural change. These include demand-driven curriculum design, low-barrier training formats and dialogue platforms that enable horizontal learning across enterprises. The formats illustrate how companies can be supported to initiate internal transformation processes through peer learning and shared problem solving.

Moreover, the analysis shows that regional and EU strategies are increasingly interlinked. Initiatives such as QualiBattBW and Voltage align with EU frameworks such as the Green Deal Industrial Plan and the Pact for Skills. They demonstrate how regional action – embedded in strong governance formats and supported by cross-border cooperation – can act as a catalyst for building resilient and responsive skills ecosystems. However, tensions remain between short-term, revenue-driven business imperatives and long-term policy goals. Overcoming this requires a well-coordinated system of multi-level governance in which regional actors translate EU ambitions into context-specific, actionable strategies, while European institutions provide the structural and financial support necessary to sustain ecosystem development and adaptability. Greater alignment between EU and regional actors is also essential to ensure global competitiveness – particularly in face of China's state-led subsidy strategies and the United States' increasingly protectionist industrial policy.

7 Conclusion

This paper has shown that workforce qualification is a strategic lever for managing structural transformation in the automotive industry, particularly for SMEs. Using the integrated lens of transformation theory and skills ecosystems, the analysis reveals how regional initiatives can close skills gaps, support organisational adaptation and foster change readiness. Baden-Württemberg's targeted qualification initiatives – such as QualiBattBW and the Strategic Dialogue missions – illustrate how territorially embedded action can advance European goals for competitiveness, resilience and a just transition.

In order to increase the effectiveness and reach of such initiatives, the following recommendations can be made: firstly, to extend low-barrier, funded and modular training formats to take account of the operational realities of SMEs; secondly, to institutionalise dialogue and feedback formats between industry, training providers and policy actors; and thirdly, to strengthen EU support for regional upskilling networks, including long-term funding and evaluation structures.

Future research should take a longitudinal perspective to assess the sustained impact of skills initiatives on workforce readiness, employment outcomes and innovation capacity. In addition, further work is needed to assess the scalability and transferability of regional approaches within the broader European skills ecosystem.

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Presenter Biography

Lena Mueller studied European Studies at the University of Passau and at the National Chengchi University in Taipei, Taiwan. She has held positions in communications in the field of mobility and technology at acatech – National Academy of Science and Engineering, The Mobility House, and Robert Bosch GmbH. Since 2025, she has been leading projects on the qualification of skilled workers for the battery industry at the State Agency for New Mobility Solutions and Automotive Baden-Württemberg e-mobil BW GmbH in Stuttgart.

Saskia Schuettke studied social and political sciences at the Universities of Stuttgart and Trondheim in Norway. In her professional career, she has worked on various aspects of electric mobility and new mobility solutions. Since 2018, she has been working for the State Agency for New Mobility Solutions and Automotive Baden-Württemberg e-mobil BW GmbH. On behalf of e-mobil BW, she leads the team Electromobility technologies and the management of the Cluster Electric Mobility South-West, and coordinates qualification-related topics within the Strategic Dialogue for the Automotive Sector in Baden-Württemberg.