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# Industry Certifications: The Alignment Between Industry and Community Colleges

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# Aligning Credentials with Industry Demand Across Electrification Technologies: A Scalable Framework for Workforce Education

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**Abstract**: The rapid expansion of electrification technologies is placing unprecedented demands on the technical workforce, while academic training programs continue to struggle with fragmented certification ecosystems, rapidly evolving skill requirements, and misalignment with industry needs. Prior work by the authors examined this challenge within the electric vehicle (EV) sector, identifying significant gaps between certifications embedded in academic programs and those valued by employers. This study extends that framework across multiple converging electrification domains including renewable energy, energy storage, and unmanned systems to evaluate whether these misalignments are domain-specific or systemic in nature.

Using a mixed-methods approach, this research integrates national academic and industry surveys, targeted interviews with employers and workforce education leaders, and preliminary big data analysis of job postings across electrification sectors. Early findings suggest that more mature workforce systems, such as renewable energy and unmanned systems, exhibit greater credential coherence and clearer alignment between industry-recognized certifications and job requirements. In contrast, less mature sectors, particularly EV-related fields, remain characterized by fragmented credentialing, inconsistent signaling to employers, and increased reliance on internal industry training due to shortages of qualified candidates.

Interview data further reveal that employers often deprioritize formal certifications in favor of hiring adaptable candidates whom they can train internally, a practice that constrains workforce scalability and diminishes the perceived value of academic credentials. Academic leaders report parallel challenges, including the high cost of certifications, difficulty maintaining faculty expertise in fast-moving technical domains, and growing competition with industry for qualified instructors.

Together, these findings indicate that credential misalignment represents a systemic workforce development challenge across emerging electrification technologies rather than

an isolated EV issue. The paper concludes with explicit policy and curricular recommendations aimed at strengthening industry/academic alignment, promoting the adoption of widely recognized baseline certifications, and supporting sustainable partnership models that enhance the relevance and impact of two-year and workforce-focused programs.

**Introduction:** The rapid expansion of electrification technologies is reshaping multiple sectors of the U.S. economy, including transportation, energy generation and delivery, manufacturing, and autonomous systems. While electric vehicles (EVs) have received significant attention as a visible driver of this transition, they represent only one component of a broader convergence that includes renewable energy (RE), energy storage (ES), utility transmission and distribution, and unmanned and autonomous systems (UMV). Across these domains, employers report persistent challenges in recruiting technicians with the skills, safety competencies, and credentials required to support deployment at scale, even as institutions of higher education (IHEs) rapidly attempt to respond to workforce demand [1–3].

A growing body of evidence suggests that workforce challenges in emerging electrification sectors are not solely the result of insufficient program availability, but rather of systemic misalignment between academic training, industry-recognized credentials, and labor market signaling mechanisms [4,5]. In prior work published in the Journal of Advanced Technological Education, the authors examined this issue within the EV sector, demonstrating a significant disconnect between the certifications embedded in community college programs and those preferred by employers [6]. That study established a mixed-methods framework combining national surveys, qualitative feedback, and sector analysis to assess credential alignment and its implications for workforce readiness.

The present study extends that framework beyond EVs to examine whether observed misalignments are specific to a single emerging technology or indicative of a broader structural issue across converging electrification workforce systems. By expanding the analysis to include RE, ES, and UMV, this work enables comparative insight across sectors at different stages of technological and workforce maturity. Early evidence suggests that more established sectors, particularly RE and UMV, exhibit greater coherence in industry-recognized certifications and clearer alignment between job requirements and training pathways, while less mature sectors remain fragmented and highly variable in credential expectations [7–9].

This research is conducted through a collaboration among multiple National Science Foundation Advanced Technological Education (NSF ATE) centers and partners, leveraging national survey data, targeted interviews with industry and academic leaders, and preliminary analysis of large-scale job posting data. Rather than focusing solely on identifying gaps, this paper emphasizes the implications of credential misalignment for workforce scalability, institutional relevance, and industry growth. In doing so, it advances explicit policy and curricular recommendations aimed at strengthening industry–academic partnerships, promoting widely recognized baseline

certifications, and supporting sustainable workforce education models across electrification technologies.

**NEVC Background and Supporting Groups**

The National Electric Vehicle Consortium (NEVC) was established to address these challenges through a collaborative effort funded by a National Science Foundation (NSF) grant. NEVC's mission is to build a national framework for EV workforce development by bringing together academic institutions, industry stakeholders, and certification bodies to discuss the needs of the space, explore current educational offerings, and, where needed, help to create standardized pathways into the electrification workforce. The grant supporting NEVC seeks to foster a national conversation that examines best practices, identifies workforce gaps, and responds to the evolving needs of the industry. This collaborative effort aims to unify fragmented programs and establish clear certification and training standards to ensure that academic and industry goals are aligned.

Among the key goals of the NEVC grant are to:

- Facilitate Networking: Establish a nationwide network of academic and industry partners to collaboratively address workforce needs, share best practices, and identify gaps in training.
- Develop Standards: Identify common certifications and competencies that align with industry needs across diverse sectors, including manufacturing, automotive repair, energy infrastructure, and cybersecurity.
- Anticipate Future Needs: Create flexible frameworks that can adapt to the rapid changes in the electrification landscape.

By fostering a national dialogue, NEVC serves as a bridge between education and industry, helping to streamline the development of new programs and certifications while ensuring that all stakeholders, educators, employers, and policymakers, are aligned in preparing the next generation of the EV workforce.

**CREATE Energy Center, an NSF ATE Center** The mission of the CREATE Energy Center is to provide a skilled technical workforce for the energy sector. The center was founded over two decades ago as a regional organization with a focus on educating STEM technicians in California. Since that time, the center has expanded its reach to all fifty states and three US territories. CREATE has addressed a wide variety of energy technologies including biomass and biofuels, wind, solar, hydro and nuclear power, electrical generation, transmission and distribution, and supervisory controls and data acquisition technology. Most recently, CREATE has expanded its study to include energy storage and the electrification of the transportation sector. The Center has also conducted a series of international studies to explore how other countries have approached education and training for the energy sector, including an examination

of the types of credentials and certifications that have been employed internationally for emerging energy technologies.

**National Center for Autonomous Technologies (NCAT), an NSF ATE Center** The mission of the National Center for Autonomous Technologies (NCAT) is to advance technician education and workforce development for autonomous and unmanned systems across multiple industry sectors. NCAT was established as a national consortium of community colleges, universities, industry partners, and government agencies with a focus on preparing skilled technicians to support rapidly evolving autonomous technologies. Since its inception, NCAT has supported education and training in areas including unmanned aerial, ground, and maritime systems; robotics and automation; sensing and perception technologies; data analytics; and integrated cyber-physical systems. NCAT's work spans diverse application domains such as aviation, agriculture, energy, defense, logistics, and infrastructure inspection, reflecting the broad deployment of autonomous systems across the economy. Through close collaboration with industry and professional societies, NCAT emphasizes industry-driven competencies, workforce-aligned certifications, and adaptable training models that respond to the dynamic nature of autonomous technology development.

**Clemson University, along with its partners Trident Technical College, Greenville Technical College and Spartanburg Community College** are developing a cross-disciplinary workforce pipeline for the EV manufacturing and service industry. A faculty-led consortium of two and four-year institutions, industry leaders, and ATE centers is working to create and pilot digital learning content designed to enhance technician education and training. The project integrates virtual and augmented reality (VR/AR) into hybrid curricula, providing immersive, interactive learning experiences for students and incumbent workers.

## Current State of Workforce

### Electrification (EV-centric systems)

Training for electrification technologies, particularly EV-related systems, remains fragmented across IHEs, with programs frequently rooted in legacy automotive or electrical disciplines that no longer reflect dominant industry needs [2,6,10]. Despite this fragmentation, targeted industry–academic partnerships demonstrate the value of coordinated credential development. Efforts led by NEVTEX and Clemson University illustrate how closer alignment with SAE has helped anchor EV training around high-voltage safety, systems integration, and workforce-relevant competencies rather than narrow repair-focused pathways [6,11]. These collaborations provide a partial counterbalance to the broader inconsistency in EV credentialing, though adoption remains uneven and employer interpretation of credentials continues to vary widely [12].

### Renewable Energy and Energy Storage

Workforce training in RE and ES is comparatively more mature, in large part due to early and sustained coordination between industry, professional societies, and IHEs. CREATE has played a

central role in pairing academic program development with NABCEP certifications, enabling clearer alignment between curriculum, credentialing, and employer expectations [7,8,13]. This approach has supported the widespread embedding of industry-recognized certifications within community and technical college programs, improving credential portability and strengthening labor market signaling [9,14]. While challenges related to cost, faculty professional development, and technology evolution persist, the RE and ES sectors demonstrate how intentional co-development of credentials and curricula can support scalable workforce systems [11,15].

**Unmanned and Autonomous Systems (UMV)**

UMV training pathways have evolved through comparatively strong alignment with industry associations and standards bodies, contributing to clearer credentialing structures despite the technical complexity of the field. NCAT has played a key role in partnering with AUVSI and related organizations to support the development and adoption of certifications such as Trusted Operator and Safe Operator credentials, particularly in areas of operations, maintenance, and safety [16–18]. These efforts have helped establish applied, modular training pathways that align with employer expectations across domains including aviation, inspection, energy, agriculture, and defense [14,19]. The UMV sector illustrates how early engagement with industry-led certification bodies can reduce ambiguity for employers and enhance the signaling value of academic programs, even as technologies continue to evolve rapidly [9,20].

**Role of NSF ATE in Credential Alignment and Workforce Partnerships**

Across all three sectors, these alignment efforts have been enabled and sustained through funding from the National Science Foundation's Advanced Technological Education (NSF ATE) program. NSF ATE has historically served as a national driver of industry–academic collaboration in technician education, particularly in emerging and rapidly evolving technical fields where traditional credentialing pathways lag workforce demand [21,22]. By supporting partnerships among IHEs, industry, and professional societies, NSF ATE has facilitated the co-development of curricula, credentials, and training models that are responsive to labor market needs while remaining accessible to students [6,9]. These investments have been especially influential in advancing "smart credentials", industry-recognized certifications embedded within academic programs that enhance employability, portability, and institutional relevance across multiple workforce sectors [23].

**Survey Details**

**Purpose of the Survey**

The purpose of this survey effort was to systematically assess the alignment between academic training programs and industry workforce needs across converging electrification sectors, with a specific focus on the role and value of industry-recognized certifications. Building on prior work that examined this alignment within the EV sector, the expanded survey framework was designed to evaluate whether similar patterns of misalignment exist across RE, ES, and UMV, and to

determine how differences in sector maturity influence credential coherence and workforce signaling [6,9]. By collecting parallel data from academic and industry stakeholders, the survey seeks to capture complementary perspectives on training priorities, certification expectations, and perceived gaps in workforce preparation.

A central objective of the survey is to move beyond anecdotal accounts of workforce challenges and provide a structured, data-driven basis for comparing how credentials are embedded, interpreted, and valued across sectors. In particular, the survey is intended to identify which certifications are commonly embedded in IHE programs, which credentials employers actively seek or recognize, and where disconnects exist that may undermine graduate employability and institutional relevance [4,11,15]. These findings are intended to inform both curricular decision-making within workforce-focused programs and broader discussions regarding policy, standardization, and industry–academic partnership models.

**Need for the Survey**

The need for this survey arises from persistent workforce shortages across electrification-related industries, coupled with widespread uncertainty regarding which credentials effectively signal technician competence to employers. Despite rapid growth in EV, RE, ES, and UMV deployments, industry stakeholders consistently report difficulty hiring qualified technicians, even as IHEs expand program offerings and credential pathways [1–3,12]. This disconnect suggests that workforce challenges are not solely driven by enrollment capacity or program availability, but by deeper structural issues related to credential fragmentation and misalignment.

Across emerging electrification sectors, training pathways have developed unevenly, often reflecting legacy disciplinary boundaries rather than current industry needs. As demonstrated in prior studies, academic programs frequently emphasize credentials that are locally convenient, historically embedded, or financially feasible, while employers prioritize safety-critical competencies, applied skills, and certifications with broad industry recognition [6,10,11]. In less mature sectors, such as EV-focused electrification, the absence of widely accepted baseline certifications has further exacerbated confusion, leading employers to deprioritize formal credentials altogether and rely instead on internal training models [12,20].

More mature sectors, particularly RE and UMV, illustrate that clearer alignment between industry-recognized certifications and academic curricula can improve workforce signaling and reduce hiring friction [9,14,16]. However, even within these sectors, challenges related to cost, faculty expertise, and rapid technological change persist, raising questions about the long-term sustainability of current training models [15,19]. A comparative, cross-sector survey is therefore necessary to distinguish sector-specific issues from systemic workforce development challenges and to identify transferable practices that can support scalable, industry-aligned technician education across electrification technologies.

**Survey Objectives**

The survey was designed to evaluate alignment between academic training programs and industry workforce needs across multiple electrification-related sectors, with particular emphasis on the role of industry-recognized certifications as labor market signals. Building on prior EV-focused work, this study extends the scope to include RE, ES, and UMV to support cross-sector comparison and identify patterns associated with workforce maturity and credential coherence [6,9]. Rather than assessing program quality in isolation, the survey focuses on how credentials are selected, embedded, interpreted, and valued across sectors.

Specifically, the survey objectives were to: (1) identify which certifications are embedded within academic programs across electrification domains; (2) determine which credentials industry stakeholders actively seek or recognize when hiring technicians; (3) compare academic placement focus with industry employment demand across sectors; and (4) identify perceived gaps, barriers, and misalignments that limit workforce scalability and credential effectiveness [11,15,20]. Collectively, these objectives support a systems-level assessment of credential alignment rather than a single-sector evaluation.

**Survey Design and Approach**

The survey employed a replicated, mixed-methods design consisting of two parallel instruments: one targeting academic respondents and one targeting industry respondents. This dual-instrument approach was selected to capture complementary perspectives while preserving comparability across electrification sectors [6,24]. Each instrument was adapted to sector-specific contexts (EV, RE/ES, and UMV) while maintaining a consistent underlying structure, allowing results to be analyzed both within and across domains.

Academic surveys were distributed to faculty, program administrators, and workforce education leaders responsible for designing or delivering technician training programs. These instruments focused on program scope, graduate placement fields, embedded certifications, and challenges related to curriculum development, faculty expertise, and credential implementation [10,11]. Industry surveys targeted employers, hiring managers, and workforce partners and emphasized hiring practices, credential preferences, perceived workforce gaps, and the practical value of certifications in employment decisions [12,16].

Replication logic was central to the survey design. Core questions and response categories were intentionally preserved across sectors to enable cross-domain comparison, while allowing limited customization to reflect sector-specific certifications and job roles [9,14]. This approach supports identification of systemic workforce alignment issues versus challenges unique to particular technologies. Survey findings were further contextualized through targeted interviews and preliminary labor market analysis, strengthening interpretation without overstating quantitative precision [20,23].

**Distribution and Participation Rate**

To assess alignment between academic training programs and industry workforce needs across electrification-related sectors, the survey instruments were distributed to a national network of academic and industry stakeholders. Distribution leveraged existing partnerships associated with NSF ATE–funded centers and consortia, including NEVC, CREATE, NCAT, and affiliated industry organizations. This approach enabled targeted outreach to respondents with direct involvement in workforce education, hiring, and credential development across EV, RE/ES, and UMV domains [6,9,23].

Survey invitations were disseminated through multiple channels, including curated mailing lists, professional networks, industry associations, and workforce-focused convenings. Academic recipients included faculty members, program administrators, and workforce education leaders from community colleges, technical colleges, and universities engaged in technician education. Industry recipients included employers, hiring managers, workforce development specialists, and industry partners operating across transportation electrification, renewable and grid-integrated energy systems, and unmanned and autonomous technologies [12,16,24].

Across all sectors, approximately 2,800 individuals were contacted, resulting in a total of 375 completed responses at the time of analysis. Of these, 308 responses were received from academic participants and 67 from industry participants. Response rates varied by sector:

1. Electrification and EV– 203 total responses with 166 from academics and 37 from industry
2. Renewable Energy and Energy Storage – 114 responses with 99 from academics and 15 from industry.
3. Unmanned and Autonomous Systems- 58 responses with 43 from academics and 15 from industry.

However overall participation levels are consistent with large-scale workforce and education surveys administered across distributed professional networks [6,11]. The higher proportion of academic responses reflects both the composition of the underlying networks and the central role of IHEs in workforce program development, while industry responses provide essential grounding in hiring practices and operational constraints.

Although response counts limit strict statistical generalization, the breadth of respondents across institutions, industries, and electrification domains supports identification of meaningful alignment patterns and recurring themes. Survey findings were therefore interpreted as indicative of systemic trends rather than definitive workforce estimates and were triangulated with interview data and preliminary labor market analysis to strengthen validity and contextual relevance [20,23].

**Interview and Labor Market Analysis**

To contextualize and validate survey findings, we conducted targeted semi-structured interviews with 14 subject-matter experts across sectors: six in Electrification/EV systems, five in Renewable Energy/Energy Storage, and three in Unmanned and Autonomous Systems. Interviewees included industry hiring managers, certification body representatives, and

workforce education leaders. Interviews focused on credential interpretation, hiring behavior, barriers to embedding certifications, and perceived workforce gaps.

In parallel, approximately 3,000 job postings across electrification-related roles were systematically reviewed and categorized to identify certifications explicitly referenced in hiring requirements. Job postings were coded for credential mention, skill emphasis, and sector alignment. This labor market scan was used to triangulate survey and interview findings and to assess the real-world signaling value of embedded academic certifications.

Together, survey responses, expert interviews, and job posting analysis provide a multi-source assessment of credential alignment across electrification domains.

**Results**

.This section presents findings from the cross-sector survey administered to academic and industry stakeholders across electrification-related domains. Findings presented below reflect triangulated analysis of 375 survey responses, 14 expert interviews, and a structured review of approximately 3,000 job postings across sectors.  Results are organized to highlight patterns of workforce engagement, sectoral focus, and credential alignment, with emphasis on similarities and differences across EV, RE/ES, and UMV. Respondent characteristics are integrated into the analysis to provide context for interpretation rather than treated as a separate descriptive section.

**Workforce Engagement and Respondent Profile**

Survey responses were received from a broad cross-section of academic and industry participants actively engaged in electrification workforce development. Academic respondents represented community colleges, technical colleges, and universities offering technician education and workforce-focused programs aligned with EV, RE/ES, and UMV. These participants included faculty members, program administrators, and workforce education leaders responsible for curriculum design, credential embedding, and employer engagement. Industry respondents included employers, hiring managers, and workforce development specialists operating across transportation electrification, renewable and grid-integrated energy systems, and unmanned and autonomous technologies [12,16,24].

Across sectors, most academic respondents reported direct involvement in programs that place graduates into electrification-related roles, while industry respondents largely indicated active hiring or management of technicians within these domains. This high level of engagement supports the relevance of the data for assessing workforce alignment, as responses reflect direct experience with training delivery, credential interpretation, and hiring practices rather than peripheral awareness [6,9]. However, variation in sectoral focus was evident, with academic respondents more heavily represented in program development and credential embedding, and industry respondents emphasizing hiring constraints, skill gaps, and on-the-job training needs.

The distribution of responses also reflects the structure of the underlying workforce ecosystem. Academic participation was higher than industry participation, consistent with prior workforce studies leveraging education-centered networks [6,11]. Industry responses, while fewer in number, spanned multiple electrification domains and provided critical insight into employer expectations and labor market realities, particularly with respect to credential signaling and workforce scalability [12,20]. As a result, findings are interpreted as indicative of alignment trends and systemic challenges rather than statistically representative estimates of the full labor market.

**Sectoral Engagement Across Electrification Domains**

Respondents reported engagement across a wide range of electrification-related fields, underscoring the converging nature of technician workforce demand. Academic respondents most frequently indicated program placement in areas historically associated with their institutional homes, including EV maintenance and repair, electrical systems, and foundational energy technologies. Industry respondents, in contrast, reported greater involvement in infrastructure-oriented roles, such as charging systems, grid integration, renewable generation, energy storage deployment, and autonomous system operations [2,10,14].

This divergence between academic placement emphasis and industry operational focus was most pronounced in EV-related training, where programs remain disproportionately concentrated in repair-oriented pathways despite industry demand shifting toward infrastructure, systems integration, and safety-critical competencies [6,12]. In RE/ES and UMV, responses suggested closer alignment between academic preparation and industry application, reflecting the influence of more established credentialing frameworks and earlier industry coordination [9,16,19]. These patterns provide an important backdrop for interpreting subsequent results related to certification embedding, employer preferences, and perceived workforce gaps.

**Embedded Certifications vs. Industry-Preferred Credentials**

Across all electrification domains, survey results reveal a consistent disconnect between the certifications embedded within academic programs and those preferred or recognized by industry employers. To provide a more concrete assessment of credential alignment, survey findings were triangulated with targeted expert interviews (n=14; EV=6, RE/ES=5, UMV=3) and a structured review of approximately 3,000 job postings across electrification-related roles. Alignment was evaluated based on the degree of convergence between certifications most frequently embedded in academic programs and those most frequently preferred or referenced by employers within each sector. Convergence patterns were categorized qualitatively as **Low**, **Medium**, **High, or Very High** based on consistency across survey responses, interview themes, and labor market references [6,9,14].

Academic respondents most frequently reported embedding certifications that were accessible, affordable, and logistically feasible within existing curricula, including locally recognized

credentials, OEM training modules, and entry-level safety certifications [10,11]. Industry respondents, by contrast, expressed stronger preference for widely recognized, industry-driven certifications that emphasize safety, systems-level understanding, and portability across employers and regions [12,16]. Table 1 summarizes cross-sector comparisons.

**Table 1. Cross-Sector Credential and Workforce Alignment**

| Sector | Certifications Most Frequently Embedded in Academic Programs | Certifications Most Referenced by Industry | Primary Academic Placement Focus | Alignment Level |
|---|---|---|---|---|
| Electrification (EV) | OEM modules, general automotive ASE, local safety certs | Multiple SAE and ASE, NFPA, and NABCEP | Vehicle maintenance/repair | **Low** |
| Renewable Energy / Energy Storage | NABCEP & OSHA | NABCEP, OSHA, and certified electrician | Solar and storage installation | **High** |
| UMV – Operations | FAA Part 107 & AUVSI Trusted Operator | FAA Part 107, AUVSI Trusted Operator | Drone operations & maintenance | **Very High** |
| UMV – Manufacturing | IACMI Certified Composites Technician, IPC soldering certifications | IACMI Certified Composites Technician, IPC-soldering, and CAD | Composite fabrication, electronics assembly | **Medium** |

Survey findings indicate that Electrification (EV-focused systems) demonstrates **low alignment** between embedded certifications and those preferred or referenced by industry. Employer responses and job posting analysis suggest inconsistent certification signaling within EV-related roles, with greater emphasis placed on prior experience or internal training pipelines rather than standardized credentials [12,20]. This divergence was most pronounced in EV-related training, where programs remain disproportionately concentrated in repair-oriented pathways despite industry demand shifting toward infrastructure, systems integration, and safety-critical competencies [6,12].

In contrast, Renewable Energy/Energy Storage and both operational and manufacturing segments of Unmanned and Autonomous Systems demonstrate much better alignment, reflecting stronger convergence between academic credentialing and employer expectations. These sectors exhibit clearer alignment with established third-party certifications, including NABCEP in RE/ES and AUVSI, FAA, IACMI, and IPC standards in UMV, consistent with prior findings regarding the value of coordinated standards development and industry consensus [9,14,16,19]. Job postings in these domains frequently referenced these certifications directly, reinforcing their labor market signaling value [14,20].

Across sectors, workforce maturity appears strongly correlated with credential coherence. Domains that engaged early with dominant professional or standards bodies demonstrate clearer signaling mechanisms and stronger curriculum alignment, whereas fragmented credential ecosystems diminish the perceived value of academic certifications and increase reliance on employer-provided internal training [6,9,23].

**Representative Interview Perspectives**

"For over a century, internal combustion vehicles shaped the standards and training systems of the automotive industry. The rapid rise of EV technology disrupted that long-standing stability, creating fragmentation in credentials and workforce alignment. As the sector matures, industry and educators are now working more deliberately to establish coherent, safety-centered standards that better align academic programs with employer needs." *Senior Representative, National Automotive Standards Organization*

"When you look at fields like nuclear or aviation, alignment isn't optional, it's built into the system because safety drives everything. The standards are clear, the certifications are established, and colleges know exactly what they need to teach. In newer electrification areas, we're still building that structure, so it takes more coordination and intentional effort to stay aligned." *Academic Workforce Administrator*

"At first, we were just trying to find people. As our processes and systems became more standardized, alignment with certifications and college programs became much more important. That's really where the renewable and energy storage sector are now." *Director Workforce Development for Large National Utility*

Together, survey data, interview insights, and labor market analysis suggest that early consolidation around widely recognized, industry-driven credentials materially improve workforce coherence and employability signaling across electrification domains [9,23].

**Perceived Gaps and Barriers**

Across sectors, both academic and industry respondents identified persistent gaps and barriers that limit effective workforce alignment, even where credential pathways exist. Academic respondents most frequently cited the high cost of industry-recognized certifications, limited access to specialized equipment, and difficulty maintaining faculty expertise in rapidly evolving technical domains as primary constraints [11,15]. These challenges were particularly acute in EV-focused programs, where certification costs and training requirements often exceed the economic capacity of students and institutions, contributing to uneven credential adoption and program sustainability concerns [6,10].

Industry respondents, while acknowledging the value of recognized certifications in principle, emphasized workforce scarcity and inconsistent credential quality as key barriers to reliance on academic credentials in hiring decisions. Employers reported difficulty distinguishing between

meaningful and superficial certifications, leading many to prioritize foundational skills, safety awareness, and candidate adaptability over formal credentials and to rely on internal training pipelines instead [12,20]. Across all sectors, respondents noted that the absence of widely accepted baseline certifications exacerbates confusion, slows workforce scaling, and weakens the signaling value of academic programs, reinforcing the need for coordinated industry–academic approaches to credential development and implementation [9,19].

**Discussion**

The findings from this study indicate that misalignment between academic credentials and industry workforce needs is not confined to a single electrification domain but rather reflects a broader structural challenge across emerging and converging technical fields. Survey results demonstrate that sectors with more mature, industry-coordinated credential ecosystems most notably RE/ES and UMV exhibit stronger alignment between embedded academic certifications and employer expectations. In contrast, EV-related training remains characterized by fragmented credential pathways, uneven adoption of industry-recognized standards, and diminished confidence in credentials as reliable signals of job readiness [6,9,14].

Insights from industry interviews further contextualize these patterns by revealing that employer reliance on certifications is highly conditional. Industry partners consistently reported that, in an ideal labor market with an adequate supply of qualified candidates, alignment with widely recognized, industry-driven certifications would be strongly preferred. However, persistent workforce shortages force employers to prioritize hiring adaptable, safety-conscious individuals regardless of formal credentials, followed by extensive internal training [12,20]. While this approach enables short-term staffing, it constrains workforce scalability, slows organizational growth, and shifts training costs from shared systems to individual employers effectively diminishing the value proposition of IHE-based credentialing.

Academic leadership interviews highlight complementary constraints on the education side of the workforce system. Deans and workforce administrators emphasized that the cost structure of many industry-recognized certifications does not align with the financial realities of community colleges or their students, particularly in programs serving nontraditional or economically constrained populations [11,15]. Respondents also noted growing difficulty in maintaining faculty expertise amid rapid technological change and competitive labor markets, with qualified instructors increasingly recruited directly into industry roles. These dynamics limit institutional capacity to sustain up-to-date programs and reinforce a cycle in which curricula lag industry evolution, further weakening credential alignment [10,19].

Taken together, these findings suggest that credential misalignment represents a systemic workforce infrastructure problem rather than a failure of individual institutions or employers. Where industry, professional societies, and IHEs have co-developed standards and credential pathways supported by sustained partnerships and external investment training ecosystems demonstrate greater coherence and resilience. Conversely, in sectors lacking such coordination,

both employers and educators are compelled to adopt stopgap strategies that reduce efficiency, limit growth, and undermine long-term workforce development objectives [9,23]. Addressing these challenges will require policy and curricular interventions that treat credentials as shared workforce infrastructure, rather than optional program enhancements, and that rebalance responsibility for training across industry, education, and public investment.

## Recommendations

The findings from this study suggest that improving workforce alignment across electrification domains requires coordinated action at the policy, curricular, and partnership levels. Rather than treating credentials as optional program enhancements, stakeholders should approach industry-recognized certifications as shared workforce infrastructure that supports scalability, portability, and employer confidence [9,23]. The following recommendations are intended to guide IHEs, industry partners, and funding agencies in strengthening credential alignment across EV, RE/ES, and UMV systems.

### Policy and Funding Recommendations.

Public investment plays a critical role in enabling credential alignment, particularly in emerging technical fields where market-driven solutions alone are insufficient. Federal and state agencies should expand support for subsidizing industry-recognized certifications embedded within academic programs, reducing cost barriers for students and institutions [11,15]. Incentive models that encourage industry participation in credential development, validation, and instruction—such as tax incentives, faculty release support, or recognition of industry subject-matter experts as adjunct instructors—could help mitigate faculty shortages and accelerate curriculum relevance [19,23]. Continued investment through NSF ATE and related programs remains essential for sustaining industry–academic partnerships that produce coherent, workforce-aligned credential ecosystems [21,22].

### Curricular and Programmatic Recommendations

IHEs should prioritize the integration of widely recognized baseline certifications that emphasize safety, systems-level understanding, and cross-sector applicability. Modular curriculum designs that align coursework with discrete, stackable credentials can improve program flexibility while preserving academic rigor and workforce relevance [6,9]. Where credential ecosystems are fragmented, institutions should avoid overreliance on narrowly scoped OEM training and instead favor credentials developed through professional societies or industry consortia with demonstrated labor market recognition [14,16]. Regular review cycles informed by employer feedback and labor market data are also necessary to ensure curricula remain responsive to evolving industry needs [10,20].

### Industry–Academic Partnership Recommendations

Employers, professional societies, and IHEs should deepen collaboration around job-task analysis, credential validation, and instructional delivery. Shared responsibility models such as co-teaching arrangements, industry-led certification preparation, and joint curriculum advisory structures can reduce the burden on academic faculty while improving employer trust in graduate competencies [12,19]. Sector examples from RE/ES and UMV demonstrate that early and sustained industry engagement in credential development leads to clearer workforce signaling and reduced hiring friction [9,16]. Replicating these models in EV and other emerging electrification domains may help shift training from reactive, employer-specific pipelines toward scalable, system-level workforce solutions.

**Accreditation and Program Approval Recommendations**

As states revisit accreditation and program approval frameworks for workforce-focused education, emerging electrification programs would benefit from evaluation criteria that place greater weight on industry relevance and credential alignment rather than sole reliance on traditional academic precedent. Recent state-level efforts to modernize accreditation processes highlight an opportunity to recognize industry partnerships, employer-validated competencies, and the embedding of industry-recognized certifications as core indicators of program quality [25]. For rapidly evolving technical fields, accreditation models anchored primarily in historical academic structures risk delaying program approval and reinforcing misalignment with workforce demand. Shifting accreditation emphasis toward demonstrated industry engagement, credential adoption, and labor market outcomes could accelerate program responsiveness while preserving rigor through externally validated standards [9,23]. Such an approach would better align emerging workforce programs with the realities of electrification industries and strengthen the long-term relevance of IHE-based credentialing systems.

**Implications for Two-Year College Programs**

For two-year college programs in particular, these findings suggest three actionable shifts.

First, credential selection should prioritize widely recognized, industry-driven baseline certifications with demonstrated labor market signaling value rather than locally convenient or narrowly scoped OEM credentials, even if doing so requires phasing out legacy offerings.

Second, institutions should proactively address cost barriers by leveraging grant funding, state workforce incentives, shared regional equipment models, and industry cost-sharing agreements to ensure that high-value certifications are financially accessible to students and sustainable for programs.

Third, advisory boards should include not only local employers, but also representatives from major certification bodies or industry associations. Involving these standards leaders helps programs stay aligned with nationally recognized credentials and reduces the risk of fragmented or outdated curriculum decisions. Together, these strategies position two-year colleges as proactive partners in building coherent, industry-aligned workforce systems.

## Conclusion

This study demonstrates that misalignment between academic training programs and industry workforce needs is a systemic challenge across emerging electrification domains rather than an issue confined to a single technology sector. By extending a previously validated survey framework beyond EVs to include RE, ES, and UMV, the findings highlight how workforce maturity, industry coordination, and credential coherence influence the effectiveness of academic credentials as labor market signals. Sectors with established industry-driven certification ecosystems exhibit stronger alignment and greater workforce scalability, while fragmented credential environments diminish employer confidence and shift training burdens away from shared systems and onto individual organizations.

Taken together, the results underscore the need to treat industry-recognized credentials as foundational workforce infrastructure supported through coordinated policy, curriculum design, and industry–academic partnerships. To advance alignment across electrification technologies, the following action items emerge from this work:

- Reframe credentials as shared workforce infrastructure by prioritizing industry-recognized, portable certifications embedded within academic programs rather than relying on fragmented or narrowly scoped credentials.
- Align accreditation and program approval processes with workforce realities by emphasizing industry validation, credential adoption, and labor market outcomes over historical academic precedent for emerging technical programs.
- Strengthen industry–academic co-development models through shared responsibility for instruction, job-task analysis, and credential validation, reducing faculty burden while improving employer trust in graduate competencies.
- Sustain and expand public investment in alignment-focused partnerships, particularly through NSF ATE and related programs, to support scalable credential ecosystems that respond to rapid technological change.

As electrification technologies continue to converge and evolve, workforce systems that integrate industry-driven credentials, flexible curricula, and responsive accreditation frameworks will be better positioned to support long-term economic growth and technician career mobility.

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