

The Role of State Management in Shaping Human Capital for Industry 4.0 in Vietnam's Power Sector

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ABSTRACT: As Vietnam's electricity industry undergoes rapid digital transformation in the context of the Fourth Industrial Revolution (Industry 4.0), human capital has emerged as a critical driver of competitiveness and innovation. This paper examines the role of state management in shaping the development of human resources to meet the new demands of an increasingly digitized and automated power sector. It reviews the current governance framework, identifies policy gaps and institutional challenges, and proposes recommendations for more adaptive, future-oriented state management. Strengthening the state's strategic role in coordinating education, training, and workforce development will be essential to building a power sector workforce that is resilient and capable of harnessing Industry 4.0 technologies.

KEYWORDS: State management, human capital, electricity sector, Industry 4.0, Vietnam, digital transformation, workforce development.

1. INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) is fundamentally reshaping industries worldwide through the convergence of advanced digital technologies, including artificial intelligence (AI), the Internet of Things (IoT), big data analytics, cloud computing, and automation (Schwab, 2016). In this evolving landscape, the electricity industry stands as both a beneficiary and an enabler of digital transformation, driving innovation across economic sectors while also undergoing profound internal change.

In Vietnam, the power sector — a strategic pillar of national economic development — is rapidly embracing Industry 4.0 innovations. The deployment of smart grids, the integration of renewable energy sources, and the progressive digitalization of grid operations and management are redefining how electricity is produced, distributed, and consumed (Nguyen & Dao, 2023). Yet, as technological capabilities advance, the human dimension of this transformation becomes increasingly critical. A digitally enabled power system demands not only cutting-edge infrastructure but also a highly skilled, adaptable, and innovative workforce.

Within this context, the role of state management in shaping human capital development is paramount. The capacity of the state to design and implement anticipatory policies, align education and training systems with emerging industry needs, and cultivate effective public-private collaboration will significantly influence the success of Vietnam's energy transition in the digital age. This aligns with broader scholarly perspectives that emphasize the importance of adaptive governance and strategic state intervention in navigating complex socio-technical transformations (Karo & Kattel, 2016; Mazzucato, 2018).

However, Vietnam's current state management approach to human capital in the electricity sector faces several structural and institutional challenges. Fragmented policy coordination, skills mismatches, and limited mechanisms for continuous workforce learning pose significant barriers to realizing the full potential of Industry 4.0 technologies. Addressing these gaps requires a more integrated, forward-looking, and dynamic model of state governance.

Against this backdrop, this paper critically examines the evolving role of state management in shaping human capital within Vietnam's power sector. Specifically, it seeks to:

- (1) analyze the current state governance framework for human capital development in the sector;
- (2) identify key policy and institutional challenges; and
- (3) propose strategic directions for enhancing state management to better support workforce transformation in line with Industry 4.0 imperatives.

By foregrounding the governance dimension of workforce readiness, this study contributes to ongoing debates on industrial policy, digital transformation, and public sector capacity in emerging economies. The findings have broader relevance for policymakers, industry leaders, and scholars concerned with fostering inclusive and sustainable energy transitions in the digital era.

2. CONCEPTUAL FRAMEWORK

2.1. Industry 4.0 and the Power Sector

The advent of Industry 4.0 marks a paradigm shift in the configuration and operation of modern power systems. This transformation is driven by the convergence of advanced digital technologies, which are enabling unprecedented levels of efficiency, flexibility, and intelligence across the entire power value chain — from generation to transmission, distribution, and end-use consumption (IEA, 2021). These developments align with broader global trends toward decarbonization, decentralization, and digitalization in the energy sector (IRENA, 2022).

Within this evolving ecosystem, several key technological applications are reshaping the contours of electricity systems:

Smart grids and digital substations, which facilitate real-time monitoring, dynamic load balancing, and bidirectional energy flows.

AI-driven predictive maintenance, enhancing asset reliability and reducing operational downtime.

IoT-enabled energy monitoring, providing granular visibility into consumption patterns and enabling demand-side management.

Integration of distributed renewable energy resources, fostering greater system flexibility and resilience.

Advanced cybersecurity measures, essential for safeguarding increasingly digital and interconnected power infrastructures.

Collectively, these innovations are not merely upgrading existing systems but fundamentally transforming the way electricity is generated, managed, and consumed (Fell et al., 2020). However, the successful deployment and scaling of these technologies hinge critically on the capabilities of the human workforce.

The complexity and interdisciplinarity of Industry 4.0 applications demand a workforce that is digitally literate, technically versatile, and capable of continuous learning (Vu et al., 2022). New competencies in data analytics, systems integration, cybersecurity, and cross-domain collaboration are becoming as essential as traditional engineering skills (Tupa et al., 2017). Moreover, the rapidly evolving technological landscape necessitates an agile and adaptive human capital base, supported by robust state-led policies for education, training, and workforce development.

Positioning human capital at the center of the power sector's Industry 4.0 transition is therefore not only a technical imperative but also a strategic governance challenge — one that requires sustained attention from both public policymakers and industry leaders..

2.2. Human Capital Requirements for Industry 4.0

The digitalization of the power sector under Industry 4.0 fundamentally reshapes the competencies required of its workforce. As advanced technologies become deeply embedded across all segments of the power value chain, the skills profile of electricity sector personnel must evolve accordingly. This evolution underscores the shift from a workforce primarily grounded in conventional electrical and mechanical engineering to one that is digitally fluent, systemically aware, and capable of navigating complex socio-technical environments (World Economic Forum, 2020).

Emerging human capital demands in the power sector are inherently interdisciplinary, cutting across traditional engineering silos and integrating new domains of knowledge and practice. Core competencies now include:

Digital and data literacy: the ability to manage, analyze, and leverage large volumes of operational and consumer data for decision-making and optimization.

Cybersecurity awareness: foundational understanding of cyber risks and protective measures critical to safeguarding digitalized power systems.

AI and machine learning basics: familiarity with the principles and applications of AI-driven tools in grid management, forecasting, and maintenance.

Systems thinking and integration: capability to conceptualize and manage interconnected technical, organizational, and market systems.

Continuous learning mindset: adaptability to rapidly evolving technological landscapes and commitment to lifelong professional development.

Beyond the acquisition of new technical skills, Industry 4.0 calls for fostering softer meta-competencies, such as innovation capacity, cross-functional collaboration, and change leadership (Pfeiffer, 2018). These attributes are critical to enabling the power sector workforce to not only operate new technologies but also to participate actively in process innovation, organizational transformation, and customer engagement.

Accordingly, human capital development strategies must adopt a holistic perspective — one that goes beyond narrow skills training to encompass broader cognitive, behavioral, and relational capabilities (Autor, 2015). This necessitates the design of integrated learning pathways that combine formal education, workplace-based training, and opportunities for experiential learning and knowledge exchange.

Moreover, the dynamism of Industry 4.0 underscores the importance of institutional mechanisms that support continuous upskilling and reskilling across the career lifecycle. In this regard, state management has a critical role to play in orchestrating multi-

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stakeholder efforts to align educational ecosystems, labor market policies, and industrial innovation agendas to meet the evolving demands of the power sector workforce..

2.3. The Role of State Management

State management constitutes a central lever in shaping the capacity of national human capital systems to respond to technological and industrial transformations (UNDP, 2020). In the context of Industry 4.0, where technological change is both rapid and disruptive, the strategic role of the state in orchestrating human capital development becomes particularly salient (Karo & Kattel, 2016). The literature on innovation governance and industrial policy increasingly recognizes that markets alone are unlikely to generate the quantity, quality, and adaptability of skills required for complex socio-technical transitions (Mazzucato, 2018). Proactive and adaptive state intervention is therefore essential.

In Vietnam's power sector, state management encompasses a range of regulatory, policy, and institutional mechanisms designed to shape human capital formation and alignment with emerging industry needs. Key dimensions of this role include:

Strategic workforce planning: anticipating future skills demand and aligning workforce development strategies with the sector's digital transformation and decarbonization objectives.

Alignment of education and training with industry needs: fostering curricular innovation and competency-based education in universities, technical and vocational education and training (TVET), and professional certification programs.

Certification and qualification frameworks: developing and maintaining flexible and transparent qualification frameworks that support both initial education and continuous skills upgrading.

Support for lifelong learning and reskilling: promoting institutional arrangements and incentive structures that enable workers at all career stages to acquire new competencies in response to technological change.

Incentivizing enterprise-based training: creating policy frameworks and financial incentives that encourage firms, particularly in the energy sector, to invest in employee training and skills development.

Facilitating public-private partnerships (PPPs): fostering collaborative arrangements between state agencies, education and training institutions, and industry actors to co-design and co-deliver human capital development initiatives.

Importantly, effective state management in this domain requires moving beyond traditional command-and-control approaches toward more networked, participatory, and adaptive governance models (Sabel & Zeitlin, 2012). This includes building institutional capacities for continuous policy learning, cross-sectoral coordination, and stakeholder engagement.

For Vietnam's power sector — which is undergoing simultaneous processes of digitalization, market liberalization, and green transition — an agile and strategic state management approach is particularly critical. Without coherent state leadership, there is a risk that human capital development efforts will remain fragmented and insufficiently aligned with the sector's evolving technological and organizational requirements. Conversely, well-designed and dynamically governed state interventions can serve as a key enabler of a future-ready power sector workforce, thereby supporting broader national development goals in the Industry 4.0 era.

An agile, responsive approach to state management is essential in the fast-evolving context of Industry 4.0.

3. CURRENT STATE MANAGEMENT IN VIETNAM'S POWER SECTOR

3.1. Governance Structure

The governance of Vietnam's power sector reflects the country's broader approach to managing strategic infrastructure sectors through a combination of centralized state oversight and gradual market liberalization (Nguyen & Dao, 2023). While the sector is increasingly exposed to global trends of digitalization and decentralization, its governance structure remains characterized by a strong role for the central state and state-owned enterprises (SOEs), particularly in shaping the trajectory of human capital development.

At the apex of sectoral governance is the Ministry of Industry and Trade (MOIT), which serves as the principal regulatory and policy authority. MOIT is responsible for developing sectoral strategies (e.g., the National Power Development Plan), setting regulatory frameworks, and overseeing major energy-related SOEs (World Bank, 2021). In parallel, the Vietnam Electricity Group (EVN) — a vertically integrated SOE — plays a dominant operational role, managing the majority of electricity generation, transmission, and distribution across the country. EVN and its subsidiaries also act as key actors in workforce training and professional development, both through internal initiatives and collaborations with external institutions.

Beyond MOIT and EVN, several other state bodies play critical roles in shaping the human capital ecosystem for the power sector:

The Ministry of Education and Training (MOET) oversees national policies for higher education and general education, including curricula relevant to science, technology, engineering, and mathematics (STEM) fields that feed into the power sector talent pipeline.

The General Department of Vocational Education and Training (GDVET), under the Ministry of Labour, Invalids and Social Affairs (MOLISA), is tasked with formulating policies and quality standards for technical and vocational education and training (TVET), which is particularly relevant for technician-level roles in the sector.

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MOLISA more broadly contributes to workforce planning, labor market regulation, and skills development initiatives across economic sectors, including energy.

Collectively, these actors form a complex and multi-layered governance system for human capital development in the power sector. However, as is often observed in sectoral governance literature (Howlett & Ramesh, 2014), coordination across these entities remains a persistent challenge. Policy fragmentation, overlapping mandates, and insufficient mechanisms for cross-sectoral dialogue often impede the development of coherent and forward-looking strategies for workforce transformation (Nguyen, 2024).

Addressing these governance bottlenecks is particularly urgent in the context of Industry 4.0, where agility, collaboration, and continuous learning are essential attributes of an effective human capital system. Building stronger institutional linkages among MOIT, MOET, MOLISA, GDVET, and EVN — as well as fostering deeper engagement with private sector and international partners — will be critical to enhancing the state's capacity to steer workforce development in alignment with the evolving demands of the digitalized power sector.

3.2. Existing State Management Tools

The Vietnamese state has deployed a range of policy instruments and strategic frameworks to guide the ongoing transformation of the power sector in alignment with Industry 4.0 imperatives. These instruments reflect both the country's broader commitment to technological modernization and the recognition of human capital development as a critical enabler of this process (MOIT, 2023; Government of Vietnam, 2021). However, as is common in the governance of complex transitions (Geels, 2019), the effectiveness of these tools depends on their coherence, adaptability, and capacity for fostering cross-sectoral alignment.

Key state management instruments currently shaping human capital development in the power sector include:

National Power Development Plan (PDP8): The latest iteration of Vietnam's long-term power sector strategy, PDP8 (MOIT, 2023), explicitly emphasizes the role of digitalization and smart grid deployment as central pillars of sectoral modernization. The plan sets targets for the integration of advanced digital technologies across generation, transmission, and distribution, thereby generating new skills requirements across the sector's workforce. However, mechanisms for translating these targets into concrete human capital development initiatives remain under-specified.

National Strategy for Industry 4.0 and related action plans: The government's overarching strategy for Industry 4.0 (Government of Vietnam, 2021) outlines broad priorities for fostering digital capabilities and innovation across economic sectors, including energy. While not sector-specific, the strategy provides a useful framework for aligning power sector workforce policies with national digital transformation goals. Implementation, however, requires more robust coordination between MOIT, MOLISA, MOET, and industry actors to avoid policy fragmentation.

Vocational training standards for electricity-related occupations: Through the General Department of Vocational Education and Training (GDVET), the state has developed competency standards for a range of electricity sector occupations. These standards serve as a foundation for aligning TVET programs with emerging industry needs. Nonetheless, challenges persist in ensuring that these standards keep pace with the rapid evolution of digital technologies and smart energy systems (Nguyen, 2024).

Digital transformation roadmaps of EVN and other SOEs: Recognizing the strategic importance of digitalization, EVN and several other large state-owned energy enterprises have developed internal digital transformation strategies and roadmaps (EVN, 2022). These roadmaps often include internal workforce development initiatives, such as training in data analytics, cybersecurity, and smart grid technologies. While promising, such efforts currently vary in scope and quality across different enterprises, underscoring the need for more consistent state guidance and benchmarking.

Taken together, these instruments demonstrate an emerging — though still incomplete — policy architecture for supporting human capital development in the context of Industry 4.0. To fully realize their potential, greater emphasis must be placed on policy coherence, cross-sectoral alignment, and institutional learning (Howlett & Ramesh, 2014). Without these elements, there is a risk that well-intentioned strategies will remain fragmented and insufficiently integrated into a comprehensive governance approach capable of equipping the power sector workforce for the demands of the digital era.

3.3. Initiatives and Progress

Despite the governance and coordination challenges outlined above, recent years have witnessed notable progress in advancing human capital development initiatives within Vietnam's power sector. These efforts, while still evolving, reflect an increasing recognition among both state and industry actors of the critical importance of workforce transformation in supporting the sector's digital and green transitions (Nguyen & Dao, 2023).

Three broad areas of progress can be observed:

Updating curricula in key universities and vocational colleges: In response to both state directives and evolving industry demand, several universities and vocational training institutions have undertaken curriculum reforms aimed at integrating Industry 4.0-related content into engineering and technical education programs. Updates include the introduction of courses on smart grid technologies, data analytics, cybersecurity, and systems integration within power systems engineering programs. However, such reforms are often uneven across institutions, with variability in both content depth and pedagogical innovation (Pham et al., 2024). Sustained state support and stronger coordination mechanisms will be required to ensure broad-based and consistent implementation.

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Launching EVN-led training centers focused on smart grid technologies: The Vietnam Electricity Group (EVN) has established a number of specialized training centers designed to upskill its workforce in areas central to the company's digital transformation strategy. These centers offer targeted training modules on smart grid operation, digital substation management, advanced metering infrastructure, and related technologies (EVN, 2022). This reflects a growing trend of SOEs taking a more proactive role in enterprise-based workforce development — a pattern observed in other transitional and emerging economies navigating Industry 4.0 transitions (Karo & Kattel, 2016).

Promoting research–industry linkages in power engineering: Efforts to strengthen collaboration between academic research institutions and the electricity industry have also gained momentum. MOIT and EVN have supported joint research programs, innovation competitions, and collaborative platforms aimed at fostering applied research in smart energy systems and digital power technologies. Such initiatives are critical to building **dynamic knowledge ecosystems** that can support both technological innovation and workforce renewal (Mazzucato, 2018). Nevertheless, ensuring the sustainability and institutionalization of these linkages remains a work in progress, with challenges related to funding stability, intellectual property management, and organizational culture alignment.

Collectively, these initiatives signal **positive movement toward a more innovation-oriented and digitally capable human capital base** in Vietnam's power sector. However, as in many sectors undergoing rapid technological change (Geels, 2019), such progress must be deepened and broadened through more systematic and coordinated state action. In particular, ensuring that initiatives move beyond **isolated pockets of excellence** to achieve **sector-wide impact** will require more robust governance mechanisms, stronger public-private partnerships, and a continuous learning orientation within state institutions themselves.

4. CHALLENGES AND GAPS

4.1. Skills Mismatch

A persistent and widening skills mismatch continues to pose a major barrier to Vietnam's ambition of building a digitally proficient and future-ready electricity sector workforce (Pham et al., 2024). The rapid introduction of new technologies — such as AI-driven grid optimization, IoT-enabled monitoring systems, and advanced data analytics — has outpaced the ability of current education and training systems to provide the necessary competencies.

Many engineers and technical staff within the power sector still operate with skills and knowledge frameworks primarily aligned to traditional electromechanical paradigms, with limited exposure to digital tools, software-driven systems, and integrated system design methodologies (Nguyen, 2024). This mismatch manifests across several dimensions:

Digital literacy and data analytics: A significant proportion of the current workforce lacks proficiency in managing and analyzing large datasets, a skill increasingly central to both operational decision-making and predictive maintenance in modern grid systems.

Systems integration and interdisciplinary thinking: Traditional education and training often emphasize narrow technical specialization, while Industry 4.0 requires competencies in systems thinking, integration across hardware and software platforms, and cross-disciplinary collaboration.

Cybersecurity awareness: With the digitalization of critical infrastructure, cybersecurity has become a foundational competency. However, many current employees lack even basic training in cyber risk awareness and mitigation strategies (Vu et al., 2022).

Change management and adaptive learning: Beyond technical skills, Industry 4.0 demands a workforce capable of engaging in continuous learning and organizational change processes. Yet, many existing staff exhibit resistance to new technologies, reflecting both cultural and institutional barriers to adaptive learning (Pfeiffer, 2018).

The persistence of this skills gap is not unique to Vietnam; similar patterns have been observed in other emerging economies navigating complex industrial transitions (World Economic Forum, 2020). However, the Vietnamese context presents specific governance challenges. These include:

Lag in updating curricula and training standards across the higher education and TVET sectors.

Limited capacity of enterprises to provide structured reskilling opportunities, particularly for mid-career professionals.

Fragmented coordination between state actors responsible for workforce planning and industrial policy, which undermines the development of coherent and responsive skills ecosystems.

Without a more strategic and coordinated approach to addressing skills mismatches, there is a significant risk that technology deployment will outstrip workforce readiness, leading to suboptimal utilization of new systems, increased operational risks, and stalled innovation diffusion (Geels, 2019). For this reason, skills policy must be treated as a core element of state management in the power sector's Industry 4.0 transition, rather than as a secondary or supporting function..

4.2. Fragmented Policy Landscape

A second major challenge constraining effective human capital development in Vietnam's power sector is the persistence of a fragmented policy landscape (Nguyen, 2024). Despite the presence of multiple national strategies — including the Industry 4.0

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Strategy, the National Power Development Plan, and sector-specific training frameworks — institutional fragmentation and weak inter-agency coordination continue to impede the development of a coherent and adaptive skills ecosystem.

The governance of human capital in the power sector is distributed across several key state actors, including the Ministry of Industry and Trade (MOIT), the Ministry of Education and Training (MOET), and the Ministry of Labour, Invalids and Social Affairs (MOLISA). Each of these entities exercises partial jurisdiction over workforce development but operates according to distinct mandates, priorities, and policy cycles. As a result:

There is a lack of integrated strategic workforce planning that systematically aligns education and training outputs with evolving sectoral skill demands under Industry 4.0.

Training standards and curricula across universities and TVET institutions are often inconsistent and insufficiently informed by forward-looking industry needs.

Policy instruments designed to support lifelong learning and enterprise-based training are fragmented and lack a clear coordinating authority.

Mechanisms for data sharing and labor market intelligence across agencies remain underdeveloped, limiting the state's ability to monitor skills gaps and respond adaptively.

These coordination failures are symptomatic of a broader governance challenge frequently observed in cross-sectoral policy domains (Howlett & Ramesh, 2014; Peters, 2015). The diffusion of authority across multiple ministries without robust coordinating mechanisms leads to policy incoherence, duplication of effort, and missed opportunities for synergies.

In the context of Vietnam's power sector, this fragmentation is particularly problematic given the pace and complexity of technological change associated with Industry 4.0. Without integrated governance, the risk increases that digitalization initiatives will proceed without corresponding investments in workforce readiness, exacerbating the skills mismatch and undermining sectoral performance.

Addressing this challenge will require not only formal mechanisms for inter-ministerial coordination — such as cross-agency task forces or joint strategic planning processes — but also the cultivation of new forms of collaborative governance (Sabel & Zeitlin, 2012). This includes fostering shared learning, joint problem-solving, and adaptive policymaking capacities across the state apparatus.

Ultimately, reducing fragmentation in human capital governance is not simply an administrative task but a strategic necessity for ensuring that Vietnam's power sector workforce is equipped to support and sustain the country's broader energy transition and digital transformation goals.

4.3. Limited Incentives for Lifelong Learning

A further critical gap in Vietnam's current human capital development framework for the power sector concerns the limited incentives for lifelong learning and enterprise-based reskilling. While the rapid evolution of Industry 4.0 technologies requires a workforce capable of continuous adaptation and learning (World Economic Forum, 2020), existing state policies do not yet provide a sufficiently supportive environment for such learning processes to flourish (Nguyen, 2024).

This limitation reflects a broader challenge faced by many emerging economies, where initial education remains the primary focus of skills policy, and mechanisms to support learning throughout the career lifecycle remain underdeveloped (OECD, 2019). In Vietnam's power sector, several specific issues can be identified:

Weak financial incentives: Current state policies provide limited fiscal or regulatory incentives for enterprises — including SOEs like EVN — to invest systematically in employee reskilling and upskilling. While some exemplary initiatives exist (Section 3.3), these are not yet embedded within a broader enabling policy framework.

Lack of structured pathways for continuous learning: National qualification frameworks and vocational standards provide limited articulation between initial training and ongoing professional development, resulting in fragmented learning pathways and insufficient recognition of informal or on-the-job learning.

Limited worker agency and motivation: Without supportive institutional structures — such as individual learning accounts, recognition of prior learning, or portable qualifications — many employees lack both the incentives and the opportunities to engage proactively in lifelong learning (Pfeiffer, 2018).

Cultural and organizational barriers: Within many traditional energy sector organizations, cultural resistance to continuous learning persists, particularly among mid-career and older workers. Changing these cultural dynamics requires both leadership commitment and supportive state policies that reward learning-oriented organizational behavior (Sabel & Zeitlin, 2012).

The consequences of these limitations are increasingly evident as technological change accelerates. Without more robust lifelong learning ecosystems, Vietnam's power sector faces the risk of a growing divide between technologically advanced infrastructure and a workforce unable to fully leverage its capabilities (Geels, 2019).

From a governance perspective, addressing this gap will require a strategic shift in state management approaches to skills policy. Rather than focusing narrowly on initial training provision, the state must develop policy instruments that actively foster

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enterprise learning cultures, support career-long skills development, and enable greater worker agency in shaping individual learning trajectories.

This shift is central to building a resilient and innovation-capable power sector workforce, and should be seen as a core priority within Vietnam's broader Industry 4.0 governance agenda..

4.4. Lagging Private Sector Engagement

An additional and closely related challenge concerns the underutilization of public-private partnerships (PPPs) in workforce development for the power sector. While Vietnam's policy discourse increasingly emphasizes the importance of collaborative governance and state-enterprise partnerships in driving Industry 4.0 transformations (Government of Vietnam, 2021), practical implementation in the domain of human capital development remains limited and fragmented.

At present, state agencies and energy companies — particularly large state-owned enterprises (SOEs) such as EVN — operate largely in parallel when it comes to workforce training and skills development. Although isolated instances of collaboration do exist — including some EVN-led initiatives in partnership with universities and vocational institutions (Section 3.3) — these remain the exception rather than the norm.

Several factors contribute to this situation:

Institutional silos and fragmented governance: As noted earlier (Section 4.2), the division of responsibilities across MOIT, MOET, MOLISA, and industry actors has led to a lack of integrated platforms for strategic dialogue and joint action on human capital issues. Without such platforms, collaborative initiatives tend to remain ad hoc and project-based.

Incentive misalignments: Existing policy frameworks do not sufficiently incentivize private enterprises — whether SOEs or emerging private energy firms — to invest in joint training programs, curriculum co-design, or shared innovation ecosystems (Nguyen, 2024). Nor do they provide robust mechanisms for recognizing or scaling successful PPP models.

Trust and capacity gaps: In many cases, mutual trust and understanding between state actors and enterprises regarding shared roles and responsibilities in workforce development remain limited. Public sector actors often view training as the domain of the state, while enterprises — particularly SOEs — may lack the incentives or internal capabilities to engage as active partners in broader skills ecosystem governance (Peters, 2015).

Limited global benchmarking and learning: Vietnam's power sector governance has yet to systematically draw on international best practices in PPPs for workforce development, such as sector skills councils, industry clusters, or regional innovation partnerships (OECD, 2019).

The result is a missed opportunity to leverage the complementary strengths of public and private actors in shaping a dynamic, responsive, and innovation-capable workforce. This is particularly problematic in the context of Industry 4.0, where fast-evolving technologies and skills demands require agile, multi-stakeholder learning ecosystems (Sabel & Zeitlin, 2012).

For state management to become more effective in this domain, a strategic shift is needed toward facilitating and institutionalizing structured public-private collaboration. This includes:

Developing formal governance mechanisms (e.g., sector skills councils or PPP platforms) to enable joint workforce planning and program design.

Introducing incentive structures (financial, regulatory, and reputational) to encourage sustained enterprise engagement in human capital development.

Fostering shared ownership of workforce transformation goals among state agencies, SOEs, private firms, and educational institutions.

Such reforms would help position Vietnam's power sector as a more collaborative and learning-oriented innovation ecosystem, better equipped to navigate the complex demands of Industry 4.0.

5. RECOMMENDATIONS

Addressing the challenges outlined above requires a more coherent, adaptive, and collaborative model of state management to support the development of a workforce that is fit for the demands of Industry 4.0. This final section offers several interrelated policy recommendations to strengthen Vietnam's approach to human capital governance in the power sector.

First, the state should prioritize the development of a comprehensive human capital roadmap for the electricity sector, fully aligned with the strategic objectives set out in the National Power Development Plan (PDP8) and the broader Industry 4.0 agenda. Such a roadmap would provide a forward-looking framework to systematically anticipate future skill needs, align educational and training provision, and support dynamic monitoring and policy learning. Its development should be pursued through an inclusive and collaborative process, involving industry representatives, educational institutions, research communities, and labor organizations, to foster shared ownership and ensure responsiveness to real-world sectoral dynamics.

Second, it is essential to enhance inter-agency coordination across the relevant governance landscape. The creation of a cross-ministerial task force— bringing together MOIT, MOET, MOLISA, GDVET, and other key stakeholders — would help address the current fragmentation of policy efforts. This task force should be mandated to coordinate education and training policies, align curricula and standards, facilitate data sharing, and jointly monitor progress toward workforce transformation goals. International

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experience suggests that such integrative governance mechanisms are vital in enabling states to manage complex industrial transitions (Sabel & Zeitlin, 2012; Howlett & Ramesh, 2014).

Third, the state should take active steps to promote lifelong learning within the power sector. This requires moving beyond a traditional focus on initial education and creating an enabling environment for continuous skills development. Policy instruments could include targeted tax incentives and recognition frameworks for companies that invest in employee reskilling and upskilling. Additionally, stronger support for modular, stackable learning pathways — linked to national qualifications frameworks — would empower workers to engage in career-long professional development.

Fourth, fostering more robust public–private collaboration is essential to building a dynamic and innovation-oriented human capital ecosystem. The state should encourage and incentivize joint curriculum development, internship programs, and enterprise-based training partnerships between universities, vocational institutions, and energy companies. Such collaboration would help ensure that education and training provision remains closely aligned with evolving industry needs and supports the development of applied, practice-oriented competencies. Moreover, it would help build stronger institutional linkages and trust between state actors and the private sector, laying the groundwork for more systemic forms of collaborative governance (Peters, 2015; OECD, 2019).

Finally, sustained attention must be given to building the institutional capacity of key state bodies, particularly MOIT and MOLISA, to manage and monitor human capital development in the power sector. This includes investing in capabilities for labor market intelligence, foresight, evaluation of training outcomes, and adaptive policy learning. Strengthening these capacities is critical to ensuring that human capital governance remains responsive and evidence-based as the sector navigates the uncertainties and opportunities of Industry 4.0 (Geels, 2019; Mazzucato, 2018).

Taken together, these recommendations point toward the need for a more strategic, integrated, and participatory model of state management — one capable of fostering the agile and innovation-ready workforce that Vietnam's power sector will require in the years ahead.

6. CONCLUSION

The ongoing transition of Vietnam's electricity sector into the Industry 4.0 era will be shaped not only by the pace of technological adoption, but equally — and perhaps more fundamentally — by the quality, adaptability, and strategic development of its human capital. As this paper has argued, the workforce represents a critical enabler of technological innovation, organizational resilience, and sustainable growth within the sector.

In this context, state management plays a pivotal role in steering the transformation of human capital systems. A business-as-usual approach — relying on fragmented governance structures, static policy instruments, and narrow conceptions of education and training — will be insufficient to meet the complex demands of the digital energy transition. Instead, the state must adopt a more coordinated, forward-looking, and partnership-driven model of governance, one capable of fostering lifelong learning, cross-sectoral collaboration, and dynamic policy learning.

Achieving this will require strategic investments in institutional capacity, inter-agency coordination, and public–private partnerships, as well as the development of a shared vision for human capital transformation across government, industry, and educational institutions. The recommendations outlined in this paper offer a starting point for such a process.

Ultimately, building an agile, innovation-ready, and inclusive workforce is not simply a technical challenge but a matter of strategic statecraft — one that will shape Vietnam's ability to achieve its broader goals of energy security, digital modernization, and sustainable development in the decades ahead..

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