

Integrating Cooperation Guideline among the Government Sector Private Sector and People Sector to Drive the Electric Vehicle Policy Towards the Goals of a Sustainable Low Carbon Society

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HOW TO CITE:

Ekkapob Simchai (2026). Integrating Cooperation Guideline Among the Government Sector Private Sector and People Sector to Drive the Electric Vehicle Policy Towards the Goals of A Sustainable Low Carbon Society. International Journal of Special Education, 41(10s), 596-614.

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ABSTRACT:

Thailand's escalating PM2.5 pollution and climate crisis have accelerated electric vehicle (EV) policy toward a low-carbon society. However, implementation faces structural limitations in infrastructure, policy integration, and stakeholder adaptation. This study examined: (1) sectoral roles in driving Thailand's EV policy; (2) structural problems and conditions for tripartite collaboration; and (3) collaborative integration guidelines for sustainable development. A Constructivist Grounded Theory approach was employed, using in-depth interviews with 24 key informants from the public, private, and civil society sectors, analyzed via the Constant Comparative Method until theoretical saturation. Four sub-categories emerged: (1) Policy Paradox, in which subsidy-driven growth concealed infrastructure gaps; (2) Collapse of the Traditional Industrial Ecosystem, marginalizing SMEs and local garages; (3) Cross-sector Policy Integration deficits; and (4) Mechanisms for a Sustainable EV Ecosystem. Civil society actors functioned as bottom-up change initiators, extending collaborative governance frameworks. A substantive theory was developed under: "Policy Integration: Bridging Infrastructure Gaps to Drive a Sustainable EV Ecosystem." Key recommendations include mandatory Data Roaming for charging networks, Extended Producer Responsibility legislation, and a Just Transition Fund for workforce reskilling. Special and vocational education must be repositioned as a strategic pillar of EV transition governance to address structural skills displacement among automotive workers and marginalized communities.

Keywords: Collaborative Integration, Electric Vehicle Policy, Low-Carbon Society, Sustainability, Policy Paradox

1. Introduction

Climate change constitutes one of the most consequential structural crises confronting the

global political economy in the twenty-first century. The Intergovernmental Panel on Climate Change (2023) has established that

anthropogenic activities-most critically the combustion of fossil fuels across production and transportation systems-are the principal drivers of average global temperature increases exceeding 1.1 degrees Celsius above pre-industrial baselines, producing cascading consequences that include intensified droughts, heat extremes, severe precipitation events, and accelerating sea-level rise. The imperative to decarbonize all major economic sectors-energy, industry, and transportation-has acquired unprecedented political urgency, and international scientific consensus now frames the clean energy transition not merely as an environmental priority but as a structural precondition for civilizational stability (IPCC, 2022).

The transportation sector constitutes one of the primary sources of global greenhouse gas emissions, responsible for approximately 23 percent of total energy-related CO₂ output, with road transport alone accounting for more than 70 percent of that share (IPCC, 2022; International Energy Agency, 2024). The entrenched dominance of internal combustion engine (ICE) vehicles in global road transport has consequently positioned the electrification of mobility as among the most strategically critical and technically feasible decarbonization pathways for meeting the objectives of the Paris Agreement (UNFCCC, 2015). The secular decline in battery pack costs documented by Nykvist and Nilsson (2015) has substantially altered the economic calculus of EV adoption, accelerating market penetration across diverse regulatory and geographic contexts. Both the International Energy Agency (2024) and BloombergNEF (2024) confirm that the global EV transition has entered an accelerating phase, with major automotive markets having committed to phasing out ICE vehicles within the coming decades.

Within Thailand's national context, transport-sector emissions are not only a contributor to global climate change but are causally implicated in the country's acute air quality crisis-particularly elevated concentrations of PM_{2.5} particulate

matter-with significant consequences for public health and economic productivity (World Health Organization, 2021). Data compiled by the Pollution Control Department (2023) indicate that road transport-predominantly older diesel vehicles-accounts for 51 to 73 percent of PM_{2.5} emissions in Bangkok and its surrounding metropolitan area, contributing to an estimated 32,300 premature deaths annually (Kiesewetter et al., 2023). These findings underscore that the reform of the national transportation system and the promotion of EVs represent not merely an environmental policy objective but a public health and economic security imperative.

Against this backdrop, Thailand has committed to achieving carbon neutrality by 2050 and net-zero greenhouse gas emissions by 2065, formalizing these commitments through the establishment of a Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS) and Nationally Determined Contribution (NDC) targets specifying greenhouse gas emission reductions of 30 to 40 percent below business-as-usual (BAU) trajectories by 2030 (UNFCCC, 2022). The Thai government has further embedded EV industrial development within its 20-Year National Strategy and the 13th National Economic and Social Development Plan (NESDC, 2023), designating the country as a major global EV production hub through the '30@30' target-whereby zero-emission vehicles are to constitute at least 30 percent of total domestic vehicle production by 2030. This ambition has been operationalized through the EV 3.0 and EV 3.5 policy packages, encompassing consumer purchase subsidies, excise tax reductions, and targeted foreign investment incentives, which have collectively precipitated rapid expansion of Thailand's EV market and positioned it among the most significant in the ASEAN region (International Energy Agency, 2024; BloombergNEF, 2024).

Notwithstanding these quantitative gains, Thailand's EV policy trajectory exhibits pronounced structural limitations. The country confronts an undersupply of charging infrastructure, persistent consumer anxiety

regarding battery costs and residual vehicle values, and the acute vulnerability of traditional automotive parts manufacturers-particularly small and medium-sized enterprises (SMEs)-whose productive capacities render them ill-positioned to integrate into EV-era supply chains. A foundational governance problem lies in the fragmented, siloed administrative architecture of relevant state agencies, which continue to operate within narrowly defined ministerial mandates without effective cross-sectoral policy integration across the domains of industry, energy, transport, and environment. The resulting coordination failures manifest as regulatory gaps, implementation redundancies, and temporal misalignments-most conspicuously the disjuncture between the rate of charging station deployment and EV registration growth, and the continued absence of comprehensive battery waste governance mechanisms (International Energy Agency, 2024; World Bank, 2025). Thailand's policy formulation process remains institutionally centralized and hierarchically top-down, structurally constraining the meaningful participation of the private sector, SMEs, and civil society in policy design-a deficit that Reed (2008) identifies as fundamentally corrosive of both the legitimacy and adaptive capacity of complex policy systems.

Compounding these governance deficiencies is a largely unaddressed human capital crisis. The technological shift from ICE to EV platforms demands a qualitatively distinct set of technical competencies-encompassing high-voltage electrical engineering, battery management systems, embedded software diagnostics, and power electronics-that Thailand's existing vocational and technical education infrastructure is structurally ill-equipped to deliver at the requisite scale. Workers in traditional automotive repair, component manufacturing, and vehicle inspection are confronted with acute occupational displacement risk, yet formal and non-formal reskilling pathways remain institutionally fragmented and chronically underfunded. Comparative evidence increasingly demonstrates that states that fail to embed targeted workforce education investments

as an integral component of EV transition governance risk precipitating social resistance that structurally undermines the political sustainability of the transition itself (Newell & Mulvaney, 2013; Heffron & McCauley, 2018).

Comparative analysis of EV policy implementation in Norway, Germany, and Japan demonstrates that durable and equitable transitions depend not on financial subsidies alone but on the coherent integration of governance mechanisms, multi-stakeholder participation architectures, enabling infrastructure, and policy designs that reconcile environmental, economic, and social equity objectives (International Energy Agency, 2024; Bjerkan et al., 2016). The analytical framework of just transition-which foregrounds the equitable distribution of transition costs and benefits, inclusive deliberative processes, and the institutional recognition of affected communities' interests and vulnerabilities (Newell & Mulvaney, 2013; Heffron & McCauley, 2018)-has accordingly emerged as an indispensable normative and analytical lens for evaluating the social sustainability of EV governance across political contexts.

This study therefore examines the current configuration, structural problems, and institutional obstacles of Thailand's EV policy implementation through the analytical frameworks of collaborative governance, low-carbon transition theory, and just transition, to develop tripartite collaborative integration guidelines for the public, private, and civil society sectors and advancing policy recommendations for strengthening Thailand's low-carbon transportation governance.

This study pursues three principal research objectives:

1.1 To examine the current state of EV policy implementation and the character of collaborative integration among the public, private, and civil society sectors in driving electric vehicle policy in Thailand.

1.2 To identify structural problems, institutional obstacles, and enabling conditions for tripartite

collaborative integration in advancing EV policy toward sustainable low-carbon society goals.

1.3 To develop evidence-based guidelines for collaborative integration among the public, private, and civil society sectors in driving EV policy toward sustainable low-carbon society goals.

2. Conceptual Framework, Theories, and Related Research

2.1 Low-Carbon Society and Electric Vehicle Policy

The low-carbon society paradigm conceptualizes economic and social development as necessarily entailing a structural reduction in greenhouse gas emissions while preserving economic competitiveness and public welfare, through the systematic transformation of energy systems, transportation infrastructure, and consumption patterns in alignment with sustainable development imperatives (Siksnelyte-Butkiene et al., 2023). EV promotion has emerged as a strategic instrument for reducing fossil fuel dependency, mitigating air pollution, and advancing national carbon neutrality objectives across a wide range of political economies, including Thailand. The International Energy Agency (2024) and BloombergNEF (2024) establish that states achieving rapid and durable EV transitions have done so not through the generosity of purchase incentives alone, but through sustained, systematic investment in enabling ecosystem conditions-including reliable charging networks, grid flexibility mechanisms, consumer protection frameworks, and structured workforce adaptation programs.

2.2 Sociotechnical Transitions and Multi-Level Perspective

From the perspective of sociotechnical systems theory, technological transition denotes not a discrete product substitution but a structural reconfiguration of the economic, industrial, and institutional systems through which a given technology is produced, maintained, and governed. The EV transition carries profound disruptive implications for the traditional automotive industry, its associated supply chains,

SMEs, and the workforce employed in ICE-dependent occupational categories-implications that are particularly acute in countries such as Thailand where the automotive sector constitutes a pillar of national industrial strategy (Kengpol, 2021). Geels (2002) systematizes this dynamic through the Multi-Level Perspective (MLP), which theorizes technological transitions as the outcome of interactions across three analytical levels: the macro-level landscape, comprising broad societal trends including climate change pressures and fossil fuel price volatility; the meso-level regime, encompassing established sociotechnical configurations-dominant technologies, incumbent industries, and regulatory frameworks-that confer structural stability to existing systems; and the micro-level niches, constituting protected innovation spaces within which radical technological alternatives incubate prior to challenging the regime. Applied to Thailand's automotive governance context, the MLP predicts that regime-level resistance from incumbent ICE-oriented industrial actors will generate significant institutional inertia, which can only be overcome through deliberately coordinated, cross-sectoral governance strategies. Markard et al. (2012) extend this analysis by demonstrating that sustainability transitions require co-evolutionary transformation across technological, institutional, market, and cultural dimensions simultaneously-a systemic challenge that single-instrument policy approaches are structurally incapable of resolving.

2.3 Collaborative Governance and Integrated Policy Frameworks

EV policy implementation is fundamentally constituted within the domain of collaborative governance, which Ansell and Gash (2008) define as a multi-actor arrangement requiring the structured cooperation of government, private sector, and civil society actors through processes of participatory deliberation, consensus formation, and resource sharing to address complex collective action problems. Given that EV policy cuts across the domains of industry, energy, transport, environment, and macroeconomic management, state-centric,

vertically organized governance architectures are structurally insufficient to generate the coordination necessary for effective implementation. Emerson et al. (2012) advance this foundation by proposing an Integrative Framework for Collaborative Governance organized around three core dimensions: principled engagement-characterized by inclusive deliberation and the construction of shared analytical understanding; shared motivation-anchored in mutual trust, reciprocal commitment, and internal legitimacy; and capacity for joint action-operationalized through procedural arrangements, institutional resources, and integrated knowledge systems. Ostrom's (1990) institutional analysis similarly demonstrates that the durable governance of common-pool resources emerges from structured collective action arrangements among relevant stakeholders rather than from hierarchical state control-a principle directly applicable to the governance of shared EV infrastructure challenges such as charging network interoperability and battery recycling systems. The Integrated Governance framework further specifies that effective public policy depends on cross-agency and cross-sectoral coordination mechanisms to eliminate siloed administrative pathologies that systematically produce redundancy, implementation delays, and strategic incoherence (Noijad, 2023). Reed (2008) underscores that substantive stakeholder participation-characterized by early and continuous engagement, procedural transparency, and genuine deliberative influence over outcomes-is essential not only for the political legitimacy of policy decisions but for the adaptive governance of complex sociotechnical transitions.

2.4 Just Transition

As EV policy accelerates the structural transformation of the automotive industry, the concept of just transition constitutes an indispensable analytical and normative framework for evaluating the political sustainability and social legitimacy of the transition. Newell and Mulvaney (2013) argue

that energy transitions structurally produce unequal distributions of costs and benefits across social groups, and that justice considerations must therefore be embedded within the institutional architecture of transition governance from the outset rather than addressed as compensatory afterthoughts. Heffron and McCauley (2018) operationalize this framework across three analytically distinct dimensions: distributive justice, concerned with the equitable allocation of transition costs and benefits; procedural justice, requiring inclusive and transparent decision-making processes; and recognition justice, entailing the institutional acknowledgment of the identities, interests, and structural vulnerabilities of affected communities. All three dimensions are directly implicated in Thailand's EV transition: the gains from EV market expansion have accrued disproportionately to large multinational manufacturers and high-income urban consumers, while transition costs have fallen heavily upon ICE-dependent SMEs and low-wage workers; the policy design process has remained predominantly hierarchical and exclusionary; and the specific vulnerabilities of traditional automotive workers have received inadequate institutional recognition.

Of particular analytical significance, Heffron and McCauley's (2018) recognition justice dimension draws explicit attention to the educational needs of technologically displaced workers as a structurally distinct and institutionally underserved population-one whose reskilling requirements cannot be adequately met through conventional academic curricula. Special and vocational education frameworks offer a theoretically grounded and empirically validated institutional mechanism for addressing this deficit: designed to be competency-based, learner-centered, and inclusive, these educational models are particularly well-suited to delivering occupational reskilling for adult workers navigating cross-technology labor market transitions. The incorporation of special education principles-including individualized learning plans, differentiated instructional approaches, and accessible delivery modalities-

into EV workforce development programs therefore constitutes a critically overlooked institutional dimension of just transition governance.

2.5 International Comparative Experience

Comparative policy analysis reveals that states successfully implementing EV transitions have characteristically deployed integrated policy architectures that coordinate economic incentives, social protection mechanisms, and enabling infrastructure investments (International Energy Agency, 2024). Norway's EV policy trajectory represents the paradigmatic case of sustainable ecosystem construction, combining demand-side incentives for EV adoption with supply-side measures including toll exemptions, priority bus lane access, and subsidized public parking, producing the highest share of EV sales in the world (Figenbaum, 2023; Bjerkan et al., 2016). Germany's strategy, by contrast, relied primarily on consumer purchase grants and tax incentives to stimulate demand; the resulting rapid sales growth during 2016 to 2023 concealed the structural fragility of a market trajectory predicated on continued fiscal transfers—a vulnerability that became acutely apparent when EV sales contracted sharply following subsidy termination in 2024 (Kühlert et al., 2025). Japan's approach under the Green Growth Strategy 2050 has pursued a gradual and technologically pluralist transition, supporting hybrid, plug-in hybrid, and hydrogen fuel-cell vehicle platforms alongside battery EVs, thereby preserving automotive supply chain continuity and attenuating the adjustment burden on domestic SMEs—a strategy explicitly oriented toward just transition principles that foreground economic and social impacts alongside environmental objectives (International Energy Agency, 2024). Thailand's government established the '30@30' policy and the EV 3.0 and EV 3.5 measures with the strategic objective of positioning the country as a regional EV production hub (National Electric Vehicle Policy Committee, 2021). Yet Thailand continues to confront significant structural constraints, including an undersupply of charging

infrastructure, underdeveloped battery waste governance, and inadequate electrical grid capacity to support projected EV penetration rates (Energy Policy and Planning Office, 2021). The World Bank (2025) identifies Thailand's fragmented, siloed governance architecture and the hierarchical top-down orientation of its policymaking process as principal institutional obstacles to achieving equitable and effective EV transition. The synthesis of this comparative literature converges on the conclusion that sustainable EV policy success requires the deliberate design of integrated governance mechanisms, the construction of genuine tripartite cooperation, and the systematic embedding of just transition principles across all dimensions of policy design and implementation—which constitutes the central analytical and normative focus of this study.

3. Methodology

This study employs a qualitative research design situated within a constructivist epistemological paradigm, applying Constructivist Grounded Theory (CGT) as developed by Charmaz (2006). The constructivist paradigm holds that knowledge is socially constituted through the interpretive interactions between researchers and participants, embedded within specific cultural, historical, and institutional contexts (Creswell, 2014). CGT is analytically appropriate for this investigation because EV policy implementation in Thailand involves structurally heterogeneous stakeholder communities with divergent interests, asymmetric power relations, and competing interpretive frameworks—dynamics best illuminated through systematic examination of actors' situated perspectives and experiential accounts (Strauss & Corbin, 1998). This methodological choice is further warranted by the multi-dimensional complexity of EV policy as a social phenomenon that intersects the domains of economic governance, energy regulation, industrial policy, environmental management, and democratic participation.

3.1 Key Informants and Sampling

The sampling frame was initially configured at 20 to 60 participants, consistent with Charmaz's (2006) grounded theory principle that sample size is not predetermined but determined iteratively by the criterion of theoretical saturation—the point at which additional data collection yields no new analytical categories or conceptual dimensions. This approach is consistent with Strauss and Corbin's (1998) position that sampling in grounded theory research is governed by emerging theoretical requirements rather than by *ex ante* statistical specifications. Participants were drawn from three analytically distinct sectors: (1) the public sector, encompassing officials from energy and industry ministries and the National Electric Vehicle Policy Committee; (2) the private sector, comprising EV charging station operators, automotive component manufacturers, and EV supply chain entrepreneurs; and (3) civil society, including current EV users, prospective purchasers, and representatives of EV user communities affected by policy implementation. Purposive sampling was applied with operationalized inclusion criteria: public sector participants were required to have a minimum of three years of direct experience in EV policy development or infrastructure governance; private sector participants were required to operate legally registered and commercially active enterprises; and civil society participants were required either to have been active EV users for a minimum of six months or to hold representative positions in EV user organizations. In subsequent phases, theoretical sampling was applied—selecting additional participants based on analytical categories emergent from prior rounds of data analysis. For instance, the identification of land-use regulation as a structural obstacle to charging station deployment prompted the targeted recruitment of additional charging station operators to enable systematic comparative analysis and theoretical category elaboration (Charmaz, 2006).

Informant selection used Purposive Sampling with specific Inclusion Criteria: public sector

informants required at least 3 years of EV policy or infrastructure experience; private sector informants must be legally registered and actively operating; civil society informants must be actual EV users for at least 6 months or representatives of EV user networks. In subsequent phases, Theoretical Sampling was applied—selecting additional informants based on data categories discovered from prior analysis. For example, when zoning laws emerged as obstacles to charging station development, additional charging station operators were interviewed for comparison and to further develop data categories (Charmaz, 2006).

3.2 Research Instruments

The primary data collection instrument was a semi-structured interview protocol developed through systematic review of the scholarly literature, theoretical frameworks, and relevant prior research, encompassing thematic domains including the current state of EV policy, the roles and functions of sectoral actors, structural problems and institutional obstacles, and guidelines for collaborative integration. The instrument was subjected to content validity assessment by three expert reviewers with established competence in public policy, public administration, and qualitative research methodology, followed by iterative revision and pilot testing with participants possessing characteristics analogous to those of the primary study population.

3.3 Data Collection

Data collection employed the zigzag strategy—involving systematic alternation between data collection and preliminary analysis phases as prescribed by Charmaz (2006)—to enable the concurrent development of theoretical categories alongside the collection of empirical material. Four data collection methods were employed:

3.3.1 In-depth Interviews: Semi-structured interviews were conducted by the researcher, with audio recordings made with the informed consent of each participant. Contemporaneous field notes documented contextual information, non-verbal behavior, conversational register, and

affective dimensions of the interview interaction to facilitate interpretive data analysis. The researcher consciously cultivated conditions of procedural openness and psychological safety to enable participants to articulate experiential knowledge and institutional perspectives with depth and candor.

3.3.2 Verbatim Transcription: Full verbatim transcription of all interview recordings was completed within the shortest feasible interval following each interview, to maximize the accuracy and completeness of the textual record and to preserve contextually significant linguistic features of participants' accounts.

3.3.3 Analytical Memo-Writing: The researcher maintained an ongoing analytical memo-writing practice throughout all phases of the research process to systematically document interpretive insights, emergent theoretical propositions, observational reflections, and preliminary hypotheses. Memo-writing served as the primary connective tissue linking the processes of data collection, systematic coding, and theoretical construction (Charmaz, 2006).

3.3.4 Documentary Analysis: Policy documents, Cabinet resolutions, inter-agency meeting records, and institutional reports from both government and private sector sources were collected and subjected to systematic analysis. Documentary data served the dual function of data triangulation-enabling cross-source verification of accounts obtained through interview-and contextual illumination of the

structural and historical dimensions of EV policy implementation (Charmaz, 2006; Creswell, 2014).

3.4 Data Analysis and Theory Building

Data analysis proceeded through the three-stage coding process prescribed by Charmaz (2006), conducted in parallel with the constant comparative method, as detailed in Table 1. Theoretical saturation was operationalized as the point at which additional interview data generated no new analytical codes, emergent categories, or previously unidentified conceptual dimensions (Charmaz, 2006; Strauss & Corbin, 1998). In this study, saturation was reached following the twenty-second to twenty-fourth interview, confirming the analytical comprehensiveness of the developed theoretical framework. Research trustworthiness was systematically verified through Lincoln and Guba's (1985) four criteria: credibility, established through iterative multi-source interviewing and member-checking procedures; transferability, ensured through the provision of thick descriptive accounts; dependability, secured through independent external auditor review; and confirmability, achieved through systematic audit trail documentation. This study received full ethical clearance from the Institutional Review Board for Human Research Ethics at Mahidol University, and written informed consent was obtained from all participants before the interview.

Table 1. Three-Level Data Coding Process Following Constructivist Grounded Theory

Coding Level	Process	Outcomes
Level 1: Initial Coding	Line-by-line coding of raw data; naming codes from informants' language (In-vivo Codes)	Numerous codes reflecting informants' behaviors, feelings, and direct experiences
Level 2: Focused Coding	Filtering and combining initial codes with aligned meanings; comparing across informants and groups	Sub-categories reflecting structural behavioral patterns
Level 3: Theoretical Coding	Connecting sub-categories; identifying causal relationships; elevating to explain the overall phenomenon	Core Category and Substantive Theory explaining the EV policy integration process

Theoretical Saturation was determined when interviewing new informants produced no additional codes, categories, or new dimensions of meaning (Charmaz, 2006; Strauss & Corbin, 1998). In this research, saturation occurred after interviewing the 22nd–24th informants, confirming that the developed theoretical framework was sufficiently comprehensive. Research trustworthiness was verified through Lincoln and Guba's (1985) four main criteria: (1) Credibility through multiple interviews and Member Checking; (2) Transferability through Thick Description; (3) Dependability through External Auditor review; and (4) Confirmability through systematic Audit Trail review. This research was approved by Mahidol University's Institutional Review Board for Human Research Ethics, and all informants signed Informed Consent forms before interviews.

5. Results

5.1 Policy Paradox

Analysis of data pertaining to the Policy Paradox theme reveals that Thailand's EV policy implementation has been structurally characterized by a fundamental contradiction: while the state has successfully accelerated EV registration growth through the EV 3.0 and EV 3.5 incentive packages, this quantitative market expansion does not yet correspond to the country's structural readiness across the critical dimensions of physical infrastructure, industrial ecosystem adaptation, governance coherence, and stakeholder preparedness for a sustainable low-carbon transition. This finding is consistent with observations by the International Energy Agency (2024) and BloombergNEF (2024) that markets sustaining durable EV adoption trajectories are distinguished not by the generosity of purchase subsidies alone, but by the depth and comprehensiveness of their enabling ecosystem investments.

The study's findings reveal that the Thai state has systematically prioritized demand-side market stimulation through fiscal transfers over the

systematic construction of an integrated and functionally coherent EV ecosystem. This policy orientation has generated a structural imbalance between the rate at which new EV users are entering the market and the capacity of existing infrastructure to support their operational needs—manifest most acutely in the insufficiency and uneven spatial distribution of charging facilities and the absence of interoperable data connectivity across competing charging service platforms. Nykvist and Nilsson (2015) caution that while the secular decline in battery costs will progressively erode price barriers to EV adoption, infrastructure deficits and governance gaps must be addressed proactively rather than assumed to self-correct through market adjustment.

Civil society participants indicated that although Thailand has progressively expanded its charging station network in numerical terms, this expansion has not produced a functionally seamless EV ecosystem, as each charging network continues to operate through proprietary application systems and data architectures, creating prohibitive transaction costs for end users attempting to locate and access services across platform boundaries.

One representative from the civil society sector (NC-05 | EV Community Founder | 5 September 2025) articulated that the policy members unanimously wish to propose to the government is the ability to charge easily through a single unified application, calling on the government to mandate cross-brand roaming. This informant further noted that such interoperability is technically achievable and that the sole remaining obstacle is political will.

The study further identified that EV market growth has proceeded without the concurrent development of battery waste governance systems or a domestic battery recycling industry, generating a structurally significant long-term policy gap in the environmental dimension—most critically, the absence of Extended Producer Responsibility (EPR) legislation and a designated

regulatory authority for overseeing the complete EV battery lifecycle. This gap carries considerable environmental risk given the projected scale of lithium-ion battery disposal at full market penetration.

Participants from both the public and private sectors consistently reported that EV policy implementation is systematically constrained by siloed administrative architectures, within which agencies continue to operate according to narrowly defined ministerial mandates without strategic cross-sectoral integration, preventing the synchronized development of energy, transport, and industrial infrastructure. Furthermore, the government's reliance on short-term demand stimulation subsidies, while

effective in accelerating sales growth, has generated structural market vulnerability by creating a demand trajectory contingent on continued fiscal transfers—a dynamic whose political risks are starkly illustrated by Germany's experience, where EV sales contracted sharply following subsidy termination (Kühlert et al., 2025). Study findings therefore establish that Thailand's EV policy 'quantitative success' does not yet reflect genuine 'structural readiness,' and that absent fundamental reform of governance mechanisms, infrastructure development, and tripartite collaborative integration, Thailand's low-carbon transportation transition risks encountering structural constraints of a systemic and self-reinforcing character in the long term (Table 2).

Table 2. Policy Paradox of Electric Vehicle Policy Implementation in Thailand

Government Measure	Positive Outcomes	Structural Gaps
EV 3.0 and EV 3.5	Rapid increase in EV registrations	Insufficient charging stations
Subsidies and Tax Reductions	Attracted foreign investment	Dependence on foreign technology
EV Production Promotion	Thailand became ASEAN EV production hub	Traditional SMEs unable to adapt in time
Demand Stimulation	Greater consumer access to EVs	Battery waste management still unclear

Analysis of the competitive dynamics of Thailand's EV market reveals that domestic operators face acute competitive pressure from foreign manufacturers—most notably Chinese brands deploying aggressive pricing strategies and high-volume marketing—that many Thai enterprises are institutionally and financially ill-positioned to withstand over extended time horizons.

Participants from the automotive repair sector reported that substantial proportions of the existing workforce lack the technical competencies in electrical systems, battery management, and embedded software required for EV servicing and maintenance, constituting a structural 'labor gap' between the competency

profiles of the incumbent workforce and the technical demands of the emerging EV industry. Newell and Mulvaney (2013) characterize this form of structural skill mismatch as a constitutive challenge of energy transition justice, arguing that absent deliberate workforce transition policy, displaced workers bear a disproportionate share of the transition's adjustment costs. The failure to establish systematic reskilling and upskilling programs risks transforming the labor gap into a persistent source of structural unemployment and social inequity. The study further identifies a critical deficiency in the secondary EV market, where the absence of universally applied Battery State of Health (SOH) assessment standards creates information asymmetries that undermine

consumer confidence in second-hand EV transactions, constituting a significant medium-term constraint on market deepening.

A structural analysis of this labor gap reveals that it is not reducible to a simple deficit in technical skills but reflects a systemic failure of the educational and vocational training architecture to anticipate and respond adaptively to technological disruption. Workers disproportionately affected by this failure—including older automotive technicians, operators of informal repair establishments, and individuals with interrupted or limited formal educational histories—are characteristically excluded from the reach of conventional training programs and require institutionally tailored educational interventions. This population exhibits a profile that the special education literature associates with significant barriers to standard instructional delivery: constrained digital literacy, disrupted educational trajectories, elevated occupational anxiety, and restricted access to formal

educational institutions. Thailand's TVET infrastructure has not yet produced the modular, competency-verified EV curricula required to serve these non-traditional learners at scale. This institutional gap represents a structurally significant policy failure at the intersection of workforce development and special education mandates, demanding urgent collaborative action across the Ministries of Education, Industry, and Labour.

Study findings establish that Thailand's EV transition constitutes not merely a technological transition but a structural transformation of the industrial system, generating sharply differentiated distributional outcomes across social groups. In the absence of effective state-designed assistance mechanisms and institutionalized just transition pathways, this distributional asymmetry risks entrenching economic inequality and eroding Thailand's long-term industrial competitiveness (Table 3).

Table 3. Structural Impacts on the Traditional Industrial Ecosystem

Affected Group	Nature of Impact
Automotive Parts SMEs	Loss of competitive capacity
Auto Repair Workshops	Lack of EV and software system skills
Spare Parts Retailers	Declining demand for ICE components
Second-hand Vehicle Market	Lack of SOH standards and consumer confidence
Traditional Workers	Risk of unemployment from technology transition

Study findings identify the development of a mandatory data roaming system for EV charging infrastructure as among the most structurally consequential near-term policy interventions. Participants from both the public and private sectors converged on the view that the government must establish universal data connectivity standards applicable to all charging network operators, enabling users to access services across provider platforms through a single interface, thereby eliminating application redundancy and substantially improving the quality of the EV user experience. Energy sector

participants additionally proposed that EV market expansion must be coordinated with investment in Smart Grid infrastructure and Vehicle-to-Grid (V2G) technology, to accommodate the increased electricity demand generated by large-scale EV adoption and to leverage EV battery capacity as distributed energy storage for national grid stabilization (Sovacool & Hirsh, 2009).

Study findings further establish that the sustainability of Thailand's EV transition is structurally conditioned on the integration of just transition principles into the core governance

architecture-most critically through attention to the distributional impacts of the transition on workers, SMEs, and traditional industry operators. Heffron and McCauley (2018) argue that all three dimensions of transition justice-distributive, procedural, and recognition-must be institutionally embedded in transition governance design rather than treated as compensatory policy supplements. In response to this structural requirement, participants across sectoral boundaries proposed the establishment of a Just Transition Fund as a dedicated institutional mechanism to support workforce skill development, facilitate SME adaptation, and create new economic opportunity structures for those adversely affected by the technology transition.

Participants further specified that this Fund must be operationalized through structured educational delivery mechanisms-not financial transfers alone. Concretely, they proposed the development of a national EV Workforce Education Program (EV-WEP), designed in accordance with special and vocational education principles to create inclusive, accessible, and competency-verified training pathways for three priority populations: displaced ICE automotive technicians requiring occupational reskilling; SME proprietors and operators requiring EV technical and digital business competencies; and workers with limited formal educational attainment requiring foundational literacy and numeracy scaffolding alongside technical EV content. Program delivery modalities would encompass community-based learning centers, digitally accessible online platforms, and industry-integrated apprenticeships-approaches with strong empirical support in special and non-formal education research as effective mechanisms for reaching marginalized adult learners.

Study findings additionally recommend the enactment of Extended Producer Responsibility (EPR) legislation governing EV battery waste, establishing binding legal obligations for manufacturers and importers to assume responsibility for the complete product lifecycle-

from production and active use through battery decommissioning, waste collection, and material recycling-thereby mitigating long-term environmental risks and creating institutional foundations for Thailand's transition to a circular economy model.

Study findings collectively indicate that advancing Thailand's EV transition toward its stated goals requires a fundamental governance reorientation-from a model of vertically organized administrative control toward a model of collaborative network governance that institutionally opens space for substantive multi-stakeholder participation in both policy design and implementation processes (Ansell & Gash, 2008; Reed, 2008).

5.5 Substantive Theory and Core Category

Drawing on the systematic analysis of data through Constructivist Grounded Theory, this study develops a substantive theory organized under the core analytical category of 'Policy Integration: Bridging Infrastructure Gaps to Drive a Sustainable EV Ecosystem,' synthesized from the relational dynamics among the policy paradox, the structural impacts on the traditional industrial ecosystem, cross-sectoral policy integration requirements, and collaborative governance mechanisms. This theoretical contribution extends the collaborative governance frameworks of Ansell and Gash (2008) and Emerson et al. (2012), and the sociotechnical transition perspective of Geels (2002) and Markard et al. (2012), by grounding and reconfiguring these frameworks within Thailand's specific policy and institutional context. The study establishes that the constitutive problem of Thailand's EV policy implementation is not the absence of articulated policy objectives but the structural limitation of siloed administrative architectures that prevent strategic connectivity across agencies and inhibit the coordinated, multi-directional governance necessary for managing complex technological transitions. The low-carbon transition simultaneously entails claims of 'structural justice' across the dimensions of labor, small enterprise, consumer, and infrastructure access (Newell &

Mulvaney, 2013; Heffron & McCauley, 2018)-claims that Thailand's current top-down, market-stimulation-oriented policy paradigm is institutionally incapable of addressing. The study's substantive theory therefore specifies that Thailand's EV policy can achieve a sustainable low-carbon society outcome only through a governance transformation in which policy

integration connects the infrastructure, industrial, energy, environmental, and social cooperation dimensions of the transition through genuine tripartite collaborative governance among the public, private, and civil society sectors-with civil society reconceptualized as an active 'bottom-up change initiator' rather than a passive policy recipient (Figure 1).

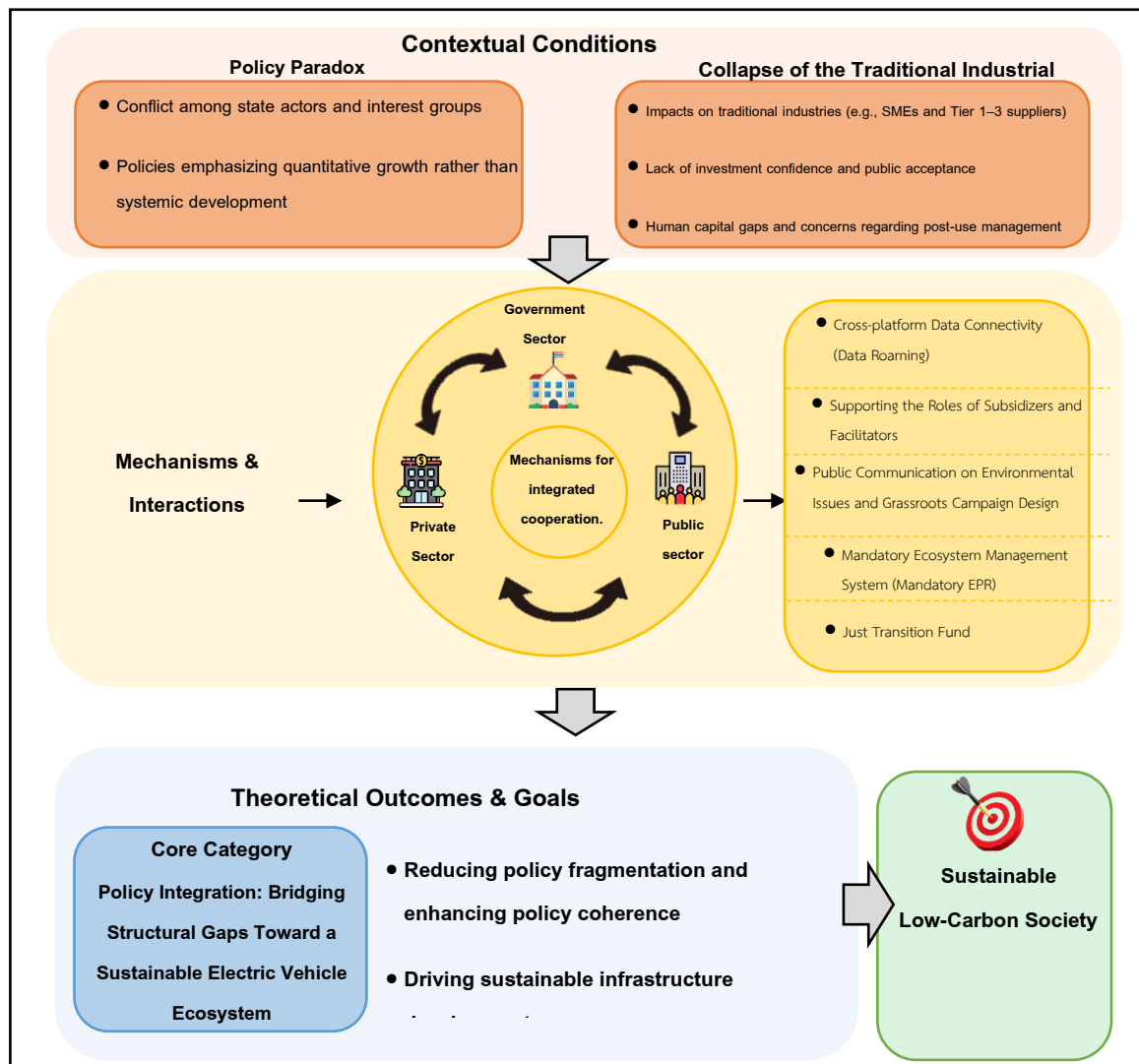


Figure 1. Substantive Theory of Electric Vehicle Infrastructure Integration Toward Sustainable Low-Carbon Society Development

6. Discussion

The findings of this study may be discussed across three principal analytical themes, each of which advances, confirms, or critically extends existing theoretical frameworks in political

science, comparative public policy, and sociotechnical transition studies.

6.1 Policy Paradox and Limitations of Short-term Demand Stimulation

The policy paradox identified in Thailand's EV policy implementation is consistent with, and analytically extends, the findings of the International Energy Agency (2024) and BloombergNEF (2024) that EV policy architectures relying exclusively on demand-side subsidies and market stimulation, without commensurate investment in enabling infrastructure and ecosystem development, systematically produce growth trajectories that are structurally fragile and temporally bounded. Germany's policy trajectory-in which EV sales contracted markedly following the termination of purchase subsidies in 2024 (Kühlert et al., 2025)-constitutes a paradigmatic illustration of this structural vulnerability, demonstrating that financial transfers absent parallel ecosystem investment fail to generate the enabling conditions for self-sustaining market development. Markard et al. (2012) establish that sustainability transitions require co-evolutionary transformation across technological, institutional, and social dimensions simultaneously-a multi-dimensional governance challenge that single-instrument subsidy policies are incapable of resolving.

The study's finding that Thailand's siloed governance architecture constitutes a primary obstacle to effective EV policy implementation is further consistent with World Bank (2025) analysis identifying institutional fragmentation as a central impediment to EV policy effectiveness in developing country contexts, and with Noijad's (2023) Integrated Governance framework specifying that cross-sectoral coordination mechanisms are a structural prerequisite for effective complex policy implementation.

6.2 Collapse of the Traditional Industrial Ecosystem and the Just Transition Dimension

The identification of a collapse of the traditional industrial ecosystem among Thai SMEs and incumbent automotive industry actors is analytically consistent with Kengpol's (2021) analysis of the structurally disruptive character of

EV transitions in countries where conventional automotive manufacturing constitutes a significant pillar of national industrial strategy, and confirms the Multi-Level Perspective's (Geels, 2002) theoretical prediction of regime-level incumbent displacement under niche-driven technological transitions. This study's findings establish that the labor gap between ICE and EV technical competencies constitutes a structural problem of the first order, requiring urgent and sustained institutional response. The normative frameworks of Newell and Mulvaney (2013) and Heffron and McCauley (2018) provide the evaluative criteria for assessing Thailand's just transition performance: measured against the distributive, procedural, and recognition dimensions of transition justice, Thailand's current EV governance architecture falls significantly short across all three. Japan's gradualist approach under the Green Growth Strategy 2050-which explicitly prioritizes automotive supply chain continuity alongside electrification ambition-offers a contextually relevant policy model for the institutional embedding of just transition considerations within national EV strategy design (International Energy Agency, 2024).

What this and comparable international cases ultimately reveal is that the workforce dimension of EV transition is, at its structural core, a challenge for the education and training system. The technical competency gap confronting Thailand's displaced automotive workers cannot be resolved through market adjustment mechanisms alone-it demands the deliberate institutional design and sustained delivery of specialized educational programs. The scholarly literature in special and vocational education consistently demonstrates that workers displaced by technological change-particularly those with lower formal educational attainment, constrained digital literacy, or occupational identities closely bound to the technology being displaced-require individually adaptive, psychologically supportive, and institutionally accessible learning environments to successfully acquire the competencies demanded by the emergent labor market (Heffron & McCauley, 2018; Newell &

Mulvaney, 2013). Thailand's EV transition thus constitutes a concrete and large-scale policy domain for the application of evidence-based special and vocational education innovations-with implications that extend well beyond the automotive sector to any industrial economy confronting the governance challenges of accelerated decarbonization.

6.3 Tripartite Collaborative Integration as a Key Condition for Sustainable EV Policy

The central finding that effective and equitable EV policy governance in Thailand requires tripartite collaborative governance is analytically consistent with and empirically confirms the collaborative governance frameworks of Ansell and Gash (2008) and Emerson et al. (2012), which establish that the resolution of complex collective action problems cannot be achieved through hierarchical state action alone but requires the institutionalization of principled engagement, shared motivation, and cross-sectoral capacity for joint action. Ostrom's (1990) institutional analysis of collective resource governance provides further theoretical grounding for the proposition that sustainable infrastructure governance emerges from structured stakeholder arrangements rather than from top-down control. Reed (2008) underscores that substantive stakeholder participation is a structural prerequisite for both policy legitimacy and the adaptive governance of complex sociotechnical systems. The substantive theory developed in this study specifies that Thailand must institutionally reorient from a model of vertical administrative control toward a model of collaborative network governance-consistent with Nojjad's (2023) Integrated Governance framework-thereby creating institutional ecosystems capable of integrating all relevant stakeholders on terms that are structurally equitable, procedurally fair, and institutionally sustainable.

6.4 Policy Recommendations

On the basis of the empirical findings and analytical discussion presented above, this study advances five principal policy recommendations for Thailand's EV governance. First, the Thai

government should establish a National EV Policy Integration Mechanism-comprising inter-ministerial joint committees drawn from the Ministries of Energy, Industry, Transport, and Natural Resources and Environment-as a permanent institutional architecture for eliminating siloed policy development and enabling the joint determination of strategic development direction (Emerson et al., 2012; Nojjad, 2023). Second, the government should enact legislation or binding administrative regulations establishing mandatory data interoperability standards for EV charging network operators, enabling all users to access services across provider platforms through a single unified system. Third, Extended Producer Responsibility (EPR) legislation for EV battery waste should be enacted, establishing legally binding obligations for manufacturers and importers to assume responsibility for the complete product lifecycle from production through decommissioning, waste collection, and material recycling. Fourth, a dedicated Just Transition Fund should be established as a permanent institutional mechanism to support systematic workforce skill development, facilitate SME structural adaptation, and generate new economic opportunity pathways for workers and enterprises adversely affected by the technology transition-directly addressing the distributive and recognition justice deficits identified by Newell and Mulvaney (2013) and Heffron and McCauley (2018).

Fifth, and of critical structural importance for the long-term human capital foundations of Thailand's EV ecosystem, the government should mandate the development and institutional delivery of a national EV Workforce Education Program (EV-WEP) through the TVET and vocational education system, co-designed through structured partnerships among industry stakeholders, special education specialists, and affected worker communities. This program should systematically adopt Universal Design for Learning (UDL) principles to ensure institutional accessibility for workers with diverse educational backgrounds, differentiated learning needs, and varying levels

of digital literacy; incorporate competency-based certification aligned with automotive industry employment standards; and deploy blended learning modalities-including community-based delivery, mobile learning units, and peer-facilitated instructional formats-to extend institutional reach to workers in peri-urban and rural areas who face disproportionate labor displacement risk and are least likely to access conventional tertiary training institutions. The institutional integration of special education frameworks into this workforce development initiative constitutes not merely a social equity commitment but a structural precondition for the human capital formation that the governance of a sustainable EV ecosystem ultimately requires.

6.5 Research Limitations and Recommendations for Future Research

Several limitations of this study warrant acknowledgment. The empirical findings derive primarily from in-depth interviews with 24 key informants based predominantly in Bangkok and the surrounding metropolitan area, which constrains the analytical generalizability of findings to the operational contexts and experiential perspectives of actors in provincial settings. Additionally, as a qualitative study designed within the Constructivist Grounded Theory tradition, the resulting theoretical framework is context-specific to Thailand's political and institutional setting and cannot be directly generalized without modification to other national contexts. Future research should extend the analytical scope through quantitative methods to enable systematic hypothesis testing derived from the developed substantive theory, and through comparative case studies across ASEAN countries with structurally analogous EV transition contexts-including Vietnam, Indonesia, and Malaysia (Markard et al., 2012)-to generate more comprehensive, comparative, and analytically portable policy knowledge.

7. Conclusion

This study examined the current state, structural problems, institutional obstacles, and collaborative integration guidelines for tripartite

governance of Thailand's electric vehicle policy transition toward sustainable low-carbon society goals, through a qualitative research design employing Constructivist Grounded Theory (Charmaz, 2006; Strauss & Corbin, 1998) and systematic in-depth interviews with 24 key informants drawn from the public, private, and civil society sectors until theoretical saturation was reached. Findings organized by research objective are as follows. With respect to the current state of EV policy implementation, Thailand has operationalized its EV ambitions through the EV 3.0 and EV 3.5 policy packages-encompassing excise tax reductions, consumer purchase subsidies, and targeted foreign direct investment incentives-which have collectively generated rapid EV market expansion and positioned Thailand among the leading EV markets in the ASEAN region (International Energy Agency, 2024; BloombergNEF, 2024). However, this policy implementation is structurally characterized by a fundamental policy paradox: while EV registrations have expanded rapidly, the country exhibits systemic unreadiness across multiple structural dimensions-including an undersupply of charging infrastructure, the absence of cross-platform data interoperability, critical gaps in battery waste governance, and a siloed administrative architecture that prevents effective cross-ministerial policy integration. The policy paradigm has been oriented toward demand stimulation rather than the construction of a structurally sustainable EV ecosystem; large-scale private sector actors and foreign manufacturers have been the primary beneficiaries of policy rents, while SMEs and traditional industry operators have been unable to adapt within the available policy timeframe; and civil society participation in the policy design process has remained institutionally marginal (Reed, 2008). With respect to structural problems, institutional obstacles, and enabling conditions for collaborative integration, this study identifies two principal problem clusters: first, structural infrastructure and governance mechanism failures-including inadequate and spatially inequitable charging infrastructure, the absence of EPR legislation for battery waste, and

siload administrative architectures that systematically obstruct cross-sectoral policy integration; and second, industrial ecosystem and just transition failures-including the structural exclusion of SMEs, automotive repair workshops, parts retailers, and secondary vehicle market operators from emerging EV value chains, the structural labor competency gap between ICE and EV technical domains (Newell & Mulvaney, 2013), and the absence of universally applicable Battery SOH assessment standards. With respect to enabling conditions, study findings specify that sustaining Thailand's EV transition requires unambiguous political will at the executive level, the institutional design of tripartite governance integration mechanisms (Emerson et al., 2012), and an explicit commitment to transition pathways that distribute costs and benefits equitably across all affected stakeholder groups (Heffron & McCauley, 2018). With respect to collaborative integration guidelines, the study establishes that advancing Thailand's EV policy toward its stated low-carbon society objectives requires the institutionalization of tripartite collaborative governance mechanisms integrating the public, private, and civil society sectors (Ansell & Gash, 2008; Ostrom, 1990), comprising three foundational policy interventions: the development of a mandatory cross-platform Data Roaming system for EV charging infrastructure; the enactment of mandatory EPR legislation establishing producer responsibility for the complete battery lifecycle from production through recycling in support of circular economy development; and the establishment of a Just Transition Fund for systematic workforce reskilling and SME structural adaptation (Newell & Mulvaney, 2013; Heffron & McCauley, 2018). The substantive theory developed under the core category 'Policy Integration: Bridging Infrastructure Gaps to Drive a Sustainable EV Ecosystem' specifies that EV policy success is structurally contingent on

the integrated governance of infrastructure, industrial, energy, environmental, and social cooperation dimensions through a collaborative governance architecture that reconstitutes civil society as an active 'bottom-up change initiator' rather than a passive policy recipient (Emerson et al., 2012; Markard et al., 2012).

8. Acknowledgements

The author wishes to express sincere gratitude to the dissertation advisory committee at the Doctor of Public Administration Program, Faculty of Social Sciences and Humanities, Mahidol University, for their invaluable guidance, scholarly insights, and constructive feedback throughout the research process. Their expertise in public policy and qualitative research methodology has been instrumental in shaping the depth and rigor of this study.

Deep appreciation is extended to all 24 key informant representatives from the public sector, private sector, and civil society who generously gave their time, knowledge, and candid perspectives. Their firsthand experiences and professional insights constitute the empirical foundation of this research. Without their willingness to participate, this study would not have been possible.

The author also acknowledges the support of colleagues and peers at Mahidol University whose intellectual discussions and encouragement contributed meaningfully to the development of this work.

This study received ethical approval from the Human Research Ethics Committee of Mahidol University (MUSSIRB No. 2024/101).

9. Author Declaration

The authors confirm that this manuscript is original, has not been published elsewhere, and is not under consideration by any other journal. The authors declare no conflicts of interest.

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