

Article

Adaptive Evolution of NEVI Implementation Across the East North Central States: A Comparative Longitudinal Analysis

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Abstract

This study examines the evolution of National Electric Vehicle Infrastructure (NEVI) implementation across the East North Central states—Illinois, Indiana, Michigan, Ohio, and Wisconsin—between 2022 and 2026 under a shared federal policy framework. The analysis is based on official federal and state documents published through 2025, with 2026 representing planned implementation targets described in the most recent state NEVI annual updates. A qualitative comparative longitudinal research design was employed using NEVI plans, annual implementation updates, Federal Highway Administration guidance, state Department of Transportation reports, and publicly available infrastructure data. Thematic analysis supported by NVivo 14 software (Lumivero, Denver, CO, USA) identified six dimensions of implementation evolution: governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation. The findings indicate that all states progressed beyond initial corridor deployment toward more adaptive and coordinated implementation approaches, although their priorities differed. Michigan and Ohio placed greater emphasis on freight mobility and interstate connectivity, Illinois strengthened institutional coordination and network expansion, Indiana focused on operational reliability and phased deployment, and Wisconsin prioritized rural accessibility and statewide coverage. This study provides a comparative longitudinal understanding of how shared federal objectives evolved into regionally distinct implementation pathways, offering insights for future EV infrastructure planning and policy implementation.

Keywords: transportation electrification; adaptive governance; sustainability transitions; electric vehicle infrastructure; sustainable transportation; National Electric Vehicle Infrastructure (NEVI) Program



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1. Introduction

Transportation electrification has emerged as a central strategy for reducing greenhouse gas emissions, improving energy efficiency, and supporting the transition toward more sustainable transportation systems. As governments seek to decarbonize the transportation sector, electric vehicle (EV) adoption has accelerated worldwide, increasing demand for reliable and accessible charging infrastructure. Consequently, the deployment of public charging networks has become a critical component of transportation planning and regional mobility strategies, particularly along major transportation corridors that support long-distance travel and interstate connectivity [1,2].

Beyond environmental benefits, transportation electrification is increasingly associated with energy security, economic competitiveness, technological innovation, and transporta-

tion system modernization. However, the transition to electric mobility extends beyond the deployment of charging stations and should be understood as a broader socio-technical transformation involving interactions among infrastructure, institutions, governance arrangements, mobility networks, and diverse stakeholder groups. Successful transportation electrification therefore depends not only on vehicle adoption but also on the ability of transportation systems to coordinate technological, organizational, and policy changes across multiple levels of governance [3,4].

Despite these opportunities, transportation electrification also presents important implementation challenges. Differences in regional infrastructure readiness, utility capacity, procurement processes, stakeholder coordination, rural accessibility, and long-term operational sustainability may affect the effectiveness of charging network deployment across jurisdictions. Previous studies have similarly emphasized that charging infrastructure availability, policy implementation, and institutional support remain critical determinants of successful transportation electrification, although these challenges vary across regional contexts [5]. Consequently, although the National Electric Vehicle Infrastructure (NEVI) Program provides a common federal framework, implementation outcomes may vary considerably depending on state-specific institutional and transportation contexts [6,7]. Understanding these differences is essential for evaluating how transportation electrification evolves in practice rather than assuming uniform implementation across all states.

Transportation electrification can therefore be viewed as a complex system in which infrastructure, institutions, policies, technologies, and users interact to shape transition outcomes. From this perspective, the deployment of EV charging infrastructure is one component of a broader transformation of the transportation system characterized by interdependent technological, organizational, and institutional change [8,9].

1.1. Transportation Electrification and the Growth of EV Infrastructure

The expansion of EV charging infrastructure plays a critical role in reducing range anxiety and improving the practicality of long-distance EV travel. Previous studies have shown that charging accessibility significantly influences EV adoption and transportation accessibility outcomes [10]. Consequently, governments increasingly view the deployment of charging infrastructure as an essential component of sustainable mobility and transportation network development.

Transportation electrification is particularly important along major transportation corridors where substantial passenger and commercial traffic occur. Corridor-based deployment strategies improve transportation connectivity by supporting continuous travel across regions and reducing infrastructure gaps between urban and rural areas. As EV adoption continues to increase, transportation planners face growing pressure to ensure that charging infrastructure supports mobility objectives while contributing to long-term transportation system resilience and operational sustainability [11].

At the same time, transportation electrification increasingly involves interactions among infrastructure systems, governance systems, freight networks, energy systems, and transportation users. These interdependencies highlight the importance of examining transportation electrification as a systems-level transition rather than solely as an infrastructure deployment initiative. These interdependencies further suggest that transportation electrification should be examined as an evolving implementation process in which policies, governance arrangements, and infrastructure priorities change over time rather than as a single infrastructure deployment event.

1.2. The Bipartisan Infrastructure Law and the NEVI Program

In the United States, the Bipartisan Infrastructure Law (BIL) established one of the largest federal investments in transportation electrification through the NEVI Program. The program provides approximately USD 5 billion to support the deployment of EV charging infrastructure along designated Alternative Fuel Corridors (AFCs) and aims to establish a connected national charging network to support interstate travel, regional mobility, and transportation system modernization [12].

The NEVI program operates through a federal–state implementation model in which states develop and update deployment strategies based on regional transportation priorities while remaining aligned with national transportation electrification objectives. Through this approach, state transportation agencies play central roles in infrastructure planning, stakeholder coordination, corridor prioritization, and charging network deployment.

Although the NEVI Program establishes common national objectives and funding requirements, states retain considerable discretion in planning, prioritizing, and implementing charging infrastructure according to regional needs. This creates an inherent tension between top-down federal policy direction and bottom-up adaptive implementation, making NEVI an appropriate setting for examining how governance processes evolve across different institutional environments.

Beyond infrastructure development, the NEVI program represents a multi-level sustainability transition process involving federal agencies, state governments, utilities, metropolitan planning organizations, private charging providers, transportation users, and regional stakeholders. The NEVI program may also be viewed as an adaptive governance process in which multiple actors interact, learn, coordinate, and continuously adjust implementation strategies in response to changing technological, institutional, and transportation conditions. Consequently, NEVI implementation provides an important opportunity to examine how transportation systems evolve through interactions among governance structures, infrastructure investments, mobility networks, and institutional adaptation processes.

1.3. Governance and Implementation Challenges

The East North Central region, comprising Illinois, Indiana, Michigan, Ohio, and Wisconsin, is an important setting for examining transportation electrification in the United States. The five states share a common federal policy framework under the NEVI program but differ substantially in population density, economic structure, institutional capacity, urbanization patterns, and transportation priorities [7,12,13].

The region encompasses both highly urbanized metropolitan areas and extensive rural communities, resulting in diverse infrastructure needs and implementation conditions. In addition, the states differ in EV adoption levels, utility coordination mechanisms, manufacturing activities, and approaches to transportation planning and infrastructure deployment. These variations offer a valuable opportunity to examine how states adapt common federal objectives to distinct regional and institutional contexts [7,14].

Beyond technical deployment, EV infrastructure implementation poses significant governance challenges, including stakeholder coordination, procurement processes, utility integration, equity considerations, operational planning, cybersecurity, and long-term infrastructure resilience. These challenges may influence implementation trajectories differently across states despite their common federal policy framework. Consequently, the East North Central region provides an appropriate setting for examining how transportation electrification evolves through continuous institutional adaptation, policy learning, and governance coordination between 2022 and 2026 [15].

1.4. Research Gap

Existing research has primarily focused on EV adoption, charging infrastructure deployment, transportation accessibility, environmental sustainability, and transportation electrification policies. While these studies provide valuable insights into EV infrastructure development and charging accessibility outcomes, they have largely examined individual aspects of transportation electrification in isolation.

Recent studies have also investigated state-level implementation experiences under the NEVI program, emphasizing infrastructure planning, charging accessibility, equity considerations, and policy implementation strategies. However, despite these contributions, existing studies have rarely explained why implementation trajectories diverge across states operating under identical federal policy requirements. As a result, the governance mechanisms, institutional adaptation processes, and policy learning that shape these differences remain insufficiently understood.

Building on prior research that examined the evolution of NEVI implementation across the New England states, the present study extends the comparative longitudinal framework to the East North Central division. Examining additional U.S. regions is important because states operate under different geographic, economic, institutional, and transportation conditions that may influence implementation trajectories despite sharing the same federal policy framework [7]. Unlike previous studies that have primarily examined EV infrastructure deployment, charging accessibility, or state implementation independently, this study adopts a comparative longitudinal perspective to investigate how governance, institutional adaptation, and implementation strategies evolved across multiple states operating under a common federal policy framework.

1.5. Study Contribution

This study contributes to the transportation electrification literature in three important ways. First, it provides a comparative longitudinal analysis of NEVI implementation across Illinois, Indiana, Michigan, Ohio, and Wisconsin from 2022 to 2026. In this study, comparative longitudinal analysis refers to the systematic examination of how implementation strategies, governance arrangements, infrastructure priorities, and institutional responses evolved over multiple implementation stages under a shared federal policy framework rather than comparing only the initial and final implementation plans. Second, the study examines how governance, infrastructure deployment, mobility considerations, freight transportation, operational sustainability, and institutional adaptation evolved throughout implementation. Third, it extends the emerging literature on transportation electrification governance by explaining how common federal policy objectives were implemented differently across states with varying regional and institutional characteristics. Collectively, these contributions provide the analytical foundation for answering the study's research question by explaining how NEVI implementation evolved across the East North Central states under a shared federal policy framework.

This study also represents the second phase of a broader national research agenda aimed at developing a comparative understanding of how NEVI implementation evolves across all U.S. Census divisions. By examining implementation across diverse regional contexts under a shared federal policy framework, the collective findings of these regional studies are expected to contribute to a national framework for understanding adaptive governance, institutional learning, and the implementation of sustainable transportation electrification in the United States.

1.6. Research Question

Accordingly, this study seeks to answer the following research question:

- How did NEVI implementation evolve across the East North Central states between 2022 and 2026 under a shared federal policy framework?

The research question is addressed through a qualitative comparative longitudinal analysis of state NEVI plans, annual implementation updates, federal guidance documents, and supporting transportation reports published between 2022 and 2026. Although the study examines NEVI implementation over the 2022–2026 implementation period, the analysis is based on official documents published through 2025, with 2026 representing planned implementation targets reported in the latest state annual updates.

2. Literature Review

Transportation electrification has become a central component of contemporary transportation planning, sustainability policy, and infrastructure development. Rapid EV adoption has heightened the importance of deploying charging infrastructure, strengthened regional transportation connectivity, and increased the need for long-term infrastructure resilience. In response, federal and state governments have implemented policies and funding programs to support the development of reliable, accessible charging networks that enable large-scale transportation electrification. Among these initiatives, the NEVI program has emerged as a significant mechanism for accelerating EV infrastructure deployment across the United States while allowing states flexibility in their implementation strategies and regional priorities. From a systems perspective, transportation electrification represents a socio-technical transition involving interactions among governance structures, infrastructure systems, mobility networks, freight systems, and institutional actors. This literature review examines the major themes relevant to the evolution of NEVI implementation, including transportation electrification and EV infrastructure development, federal transportation policy, regional transportation connectivity through AFCs, governance and institutional coordination, equity and accessibility, operational sustainability, freight mobility, and adaptive governance. Together, these themes provide the theoretical and contextual foundation for examining the evolution of NEVI implementation across the East North Central states between 2022 and 2026.

2.1. Transportation Electrification and EV Infrastructure Development

Transportation electrification has become a key strategy for reducing greenhouse gas emissions and supporting sustainable mobility systems. The transportation sector remains one of the largest contributors to global carbon emissions, underscoring the importance of EV adoption as part of broader decarbonization efforts [16]. As governments continue to promote EV adoption through incentives and infrastructure investments, transportation electrification has become a central component of modern transportation planning.

The rapid growth of the EV market has increased demand for accessible, reliable charging infrastructure. Some studies indicate that charging availability is among the most influential factors affecting EV adoption, while insufficient infrastructure remains a major barrier to market expansion [2,3]. Consequently, governments have increasingly prioritized deploying charging networks to support both local and long-distance travel.

Public charging infrastructure plays an important role in reducing range anxiety and improving transportation accessibility. Fast-charging stations along major transportation corridors enable longer trips and strengthen regional transportation connectivity, making EVs more practical for everyday travel and interstate mobility [3]. Furthermore, charging infrastructure has become a critical component of transportation systems that seek to balance sustainability, accessibility, and operational efficiency.

Despite substantial progress in EV adoption and infrastructure deployment, challenges remain regarding charging network coverage, accessibility, and long-term reliability. These challenges have prompted governments to develop large-scale transportation electrification initiatives to expand charging infrastructure while supporting future mobility demands [16,17]. While some studies have primarily examined EV adoption, charging accessibility, or infrastructure expansion, they have generally focused on static assessments rather than examining how implementation evolves over time across multiple jurisdictions operating under a common federal policy framework. The present study addresses this limitation through a comparative longitudinal analysis of NEVI implementation.

2.2. *The National Electric Vehicle Infrastructure Program*

The transition toward transportation electrification in the United States has been supported by federal policies that accelerate EV infrastructure deployment and improve regional transportation connectivity. Among these initiatives, the Bipartisan Infrastructure Law established a comprehensive framework for expanding EV charging networks through coordinated investments and state-level implementation strategies [18,19].

A central component of this legislation is the NEVI Formula Program, which provides federal funding to states to deploy EV charging infrastructure along designated transportation corridors. The program aims to create a reliable, interconnected charging network that supports local mobility and long-distance travel while reducing barriers to EV adoption [20].

The implementation of NEVI is closely linked to the development of AFCs, which form the foundation for corridor-based charging infrastructure planning. AFCs are intended to improve network continuity, reduce charging gaps, and facilitate interstate travel by ensuring the availability of charging facilities along major transportation routes [21].

Unlike traditional infrastructure programs, NEVI uses a federal–state implementation model in which federal agencies set funding requirements and performance expectations, while state transportation agencies retain flexibility in planning and deployment decisions. This approach enables states to address regional transportation needs while advancing broader national transportation electrification objectives [22].

The level of infrastructure funding provided through NEVI reflects the growing recognition that charging accessibility is essential to transportation electrification. As states continue to implement their deployment plans, the program offers an important opportunity to examine how infrastructure investments, corridor development, and implementation strategies evolve under a shared federal policy framework.

2.3. *Alternative Fuel Corridors and Regional Transportation Connectivity*

Alternative Fuel Corridors (AFCs) have become an important part of transportation electrification by supporting the deployment of EV charging infrastructure along major highway networks. The corridor-based approach aims to improve charging accessibility, reduce range anxiety, and support long-distance EV travel through a connected charging network [3,23].

Regional transportation connectivity depends on the continuity of charging infrastructure across state borders. Prior studies indicate that reliable charging networks along transportation corridors increase travel confidence and support interstate mobility by reducing gaps in charging availability [20,24]. Consequently, corridor readiness has become a key consideration in transportation planning and EV infrastructure deployment.

The East North Central region is an important setting for examining transportation connectivity because Illinois, Indiana, Michigan, Ohio, and Wisconsin are linked

by major interstate corridors, including I-90, I-94, I-80, I-70, I-65, and I-75. These corridors support both passenger and freight movement, making the region well-suited to evaluating how corridor electrification contributes to regional mobility and network continuity [23].

2.4. Governance Systems and Institutional Coordination in Transportation Electrification

The successful deployment of EV infrastructure depends on the effective coordination of multiple actors operating across interconnected governance systems. Transportation electrification involves interactions among federal agencies, state departments of transportation (DOTs), utilities, metropolitan planning organizations (MPOs), local governments, private charging providers, and other stakeholders, collectively influencing planning, implementation, and operational outcomes. As a result, EV infrastructure deployment extends beyond technical infrastructure development and reflects the broader governance structures that shape transportation system transformation [25,26].

State DOTs play a central role within these governance systems by coordinating infrastructure planning, corridor development, stakeholder engagement, and funding allocation. Utilities contribute technical expertise in grid capacity, energy demand management, and charging operations, while MPOs and local governments support regional transportation planning and implementation. The effectiveness of transportation electrification initiatives therefore depends on the ability of these organizations to collaborate across institutional boundaries and align their activities toward shared transportation objectives [25,26].

Institutional coordination also extends beyond public-sector organizations to include private charging providers, technology firms, and other industry participants. Public-private partnerships have emerged as important governance mechanisms that combine governmental support with private-sector investment, operational expertise, and technological capabilities. Such collaborative arrangements can accelerate infrastructure deployment, improve implementation efficiency, and enhance the long-term sustainability of transportation electrification programs [2,27].

From a systems perspective, governance structures represent an essential component of transportation electrification because they facilitate interactions among infrastructure systems, mobility networks, energy systems, and institutional actors. Several studies suggest that effective governance systems improve coordination, reduce implementation barriers, and support adaptive responses to emerging technological and operational challenges [28,29].

Recent studies emphasize the importance of adaptive governance in managing the complexity of transportation electrification. Adaptive governance encourages collaboration, flexibility, and continuous learning among stakeholders, allowing institutions to respond to evolving technological, regulatory, and transportation challenges [28,29]. Consequently, governance systems and institutional coordination are increasingly recognized as critical factors influencing the long-term evolution, resilience, and effectiveness of transportation electrification initiatives.

2.5. Equity and Accessibility in Transportation Electrification

Equity has become a central consideration in transportation electrification policies as governments work to ensure that the benefits of EV infrastructure are shared across diverse communities. Programs such as Justice40 emphasize directing investments toward disadvantaged and underserved populations that have historically had limited access to transportation resources and greater exposure to environmental burdens [30,31]. As a

result, equity considerations are increasingly integrated into EV infrastructure planning and deployment strategies.

Despite the expansion of charging networks, accessibility gaps persist between urban and rural areas. Rural communities often face lower charging station density, longer travel distances, and limited private investment, creating what some studies describe as “charging deserts” [32]. These disparities may hinder EV adoption and diminish the effectiveness of transportation electrification initiatives in less-populated regions.

Addressing these challenges requires developing inclusive transportation systems that prioritize accessibility alongside infrastructure growth. Several studies suggest that equitable deployment of charging infrastructure can improve transportation access, support regional mobility, and reduce disparities in EV adoption across socioeconomic groups [1,33]. Consequently, equity and accessibility have become essential components of long-term transportation electrification planning.

2.6. Operational Sustainability and Infrastructure Resilience

The long-term success of transportation electrification depends not only on infrastructure deployment but also on the operational performance of charging networks. Reliability and maintenance are critical factors influencing user confidence, as malfunctioning or unavailable charging stations may discourage EV use and reduce the effectiveness of transportation electrification initiatives [34].

As charging infrastructure expands, cybersecurity and grid resilience have become increasingly important considerations. Charging networks are connected to digital communication systems and electrical grids, creating potential vulnerabilities that may affect operational continuity and service reliability. Some studies emphasize the need for resilient infrastructure systems capable of adapting to technological disruptions, cyber threats, and increasing electricity demand associated with EV growth [35].

Interoperability is another key component of infrastructure resilience because it enables EV users to access charging services across different networks and providers. Research suggests that interoperable charging systems improve user experience, support regional mobility, and enhance network efficiency by promoting seamless access to charging infrastructure [36]. Consequently, operational sustainability has become an essential consideration in the long-term planning and management of EV infrastructure systems.

2.7. Freight Mobility and Transportation Network Electrification

Freight transportation plays a critical role in the U.S. economy, supporting the movement of goods through interconnected highway, logistics, and supply chain networks. As transportation electrification expands, attention has increasingly turned to electrifying commercial transportation systems, particularly along major freight corridors that facilitate interstate commerce [37]. The transition to electric freight vehicles has the potential to reduce emissions while improving the sustainability of freight operations.

The electrification of freight transportation poses distinct infrastructure challenges compared with passenger vehicle travel. Heavy-duty vehicles require higher charging capacities, strategically located charging stations, and reliable corridor networks that support long-distance freight movement [38]. Consequently, transportation agencies and logistics providers have increasingly recognized the importance of integrating truck electrification into broader transportation planning strategies.

The East North Central region contains some of the busiest freight corridors in the United States, linking major manufacturing, logistics, and commercial centers via interstate routes including I-90, I-94, I-80, I-70, I-65, and I-75. These corridors support substantial

freight activity and interstate commerce, making the region particularly relevant for examining how transportation electrification may affect future logistics networks, supply chain mobility, and freight transportation systems [38,39].

2.8. Adaptive Governance and Transportation System Transition

The transition toward transportation electrification represents a complex socio-technical transformation that requires coordinated action among governments, industries, utilities, transportation agencies, and other stakeholders. Sustainability transition theory suggests that large-scale technological transformations emerge through interactions among policy frameworks, infrastructure systems, institutional arrangements, and societal actors rather than through technological innovation alone [8,40]. Consequently, the transition toward EV transportation systems requires not only infrastructure deployment but also governance adaptation, institutional change, and continuous coordination among multiple actors operating within an evolving transportation system.

From a systems perspective, transportation electrification may be understood as an adaptive governance process in which technological, organizational, policy, and social components interact and evolve over time. Changes in infrastructure deployment, governance arrangements, stakeholder participation, and transportation demand can influence the behavior of the broader system, creating dynamic relationships that shape implementation outcomes. As a result, successful transportation transitions depend on the ability of institutions and stakeholders to adapt to changing environmental, technological, and policy conditions [8,40].

Adaptive governance has emerged as an important approach for managing complex transitions characterized by uncertainty, technological change, and evolving stakeholder needs. Unlike traditional governance models, adaptive governance emphasizes flexibility, collaboration, policy learning, and continuous adjustment of implementation strategies in response to emerging challenges and opportunities [41,42]. This approach is particularly relevant to transportation electrification because infrastructure deployment, technological innovation, user adoption, and transportation needs continue to evolve throughout the implementation process.

Institutional adaptation, policy learning, and collaborative governance are therefore critical components of transportation system transformation. Some studies emphasize that organizations capable of learning from implementation experiences, sharing knowledge across institutional boundaries, and adapting governance practices are better positioned to support long-term sustainability objectives and infrastructure transformation efforts [43]. Such adaptive capacities contribute to the resilience and effectiveness of transportation systems by enabling stakeholders to respond to changing conditions while maintaining progress toward strategic goals.

Collectively, sustainability transition theory and adaptive governance provide a useful foundation for understanding transportation electrification as a dynamic sustainability transition process. While Sustainability Transition Theory explains the broader processes through which socio-technical systems evolve toward sustainability, Adaptive Governance explains the institutional mechanisms that enable governments and stakeholders to respond to changing technological, organizational, and policy conditions during that transition [44]. Accordingly, the two theories are complementary rather than competing perspectives. These perspectives highlight how governance structures, infrastructure investments, mobility networks, institutional arrangements, and stakeholder interactions co-evolve throughout implementation processes. Accordingly, they provide an appropriate theoretical lens for examining how states adapt their strategies, policies, and implementation approaches as NEVI deployment evolves between 2022 and 2026. By integrating these complementary

theoretical perspectives within the context of NEVI implementation, this study extends existing transportation electrification research beyond infrastructure deployment to explain how governance adaptation and institutional learning shape implementation trajectories over time.

2.9. Conceptual Framework

This study develops a conceptual framework to examine the evolution of NEVI implementation across the East North Central states from 2022 to 2026. The framework recognizes that transportation electrification extends beyond the deployment of charging infrastructure and involves interactions among governance arrangements, infrastructure development, transportation connectivity, freight mobility, operational sustainability, and institutional learning. These dimensions collectively shape how states implement transportation electrification initiatives under a shared federal policy framework.

The framework begins with the federal policy environment established by the Bipartisan Infrastructure Law and the NEVI Formula Program, which provide common funding mechanisms, implementation requirements, and national transportation electrification objectives. Within this shared policy environment, states develop implementation strategies that reflect their unique geographic, economic, institutional, and transportation conditions.

The framework further assumes that effective implementation depends on governance and stakeholder coordination among state departments of transportation, utilities, metropolitan planning organizations, local governments, private-sector charging providers, and other participating organizations. These governance processes influence infrastructure deployment decisions, charging network expansion, corridor prioritization, and implementation activities.

As implementation progresses, infrastructure deployment contributes to broader transportation outcomes by improving regional connectivity, supporting interstate mobility, facilitating freight transportation, and strengthening transportation accessibility. At the same time, states increasingly address operational sustainability issues, including reliability, maintenance, resilience, interoperability, cybersecurity, and long-term infrastructure performance.

Finally, the framework recognizes that implementation is not static. State agencies continuously adjust policies, refine strategies, strengthen partnerships, and incorporate lessons learned throughout the implementation process. These adaptive processes contribute to institutional learning and shape the evolution of NEVI implementation over time.

Figure 1 presents the conceptual framework guiding this study and illustrates how federal policy guidance, governance processes, infrastructure deployment, transportation outcomes, and institutional learning collectively influence the evolution of transportation electrification implementation across the East North Central states between 2022 and 2026. The framework assumes that federal policy provides the external implementation environment, while governance processes influence infrastructure deployment and stakeholder coordination. These implementation activities subsequently affect transportation connectivity, freight mobility, operational sustainability, and institutional learning, creating a continuous process of adaptive implementation throughout the NEVI program.

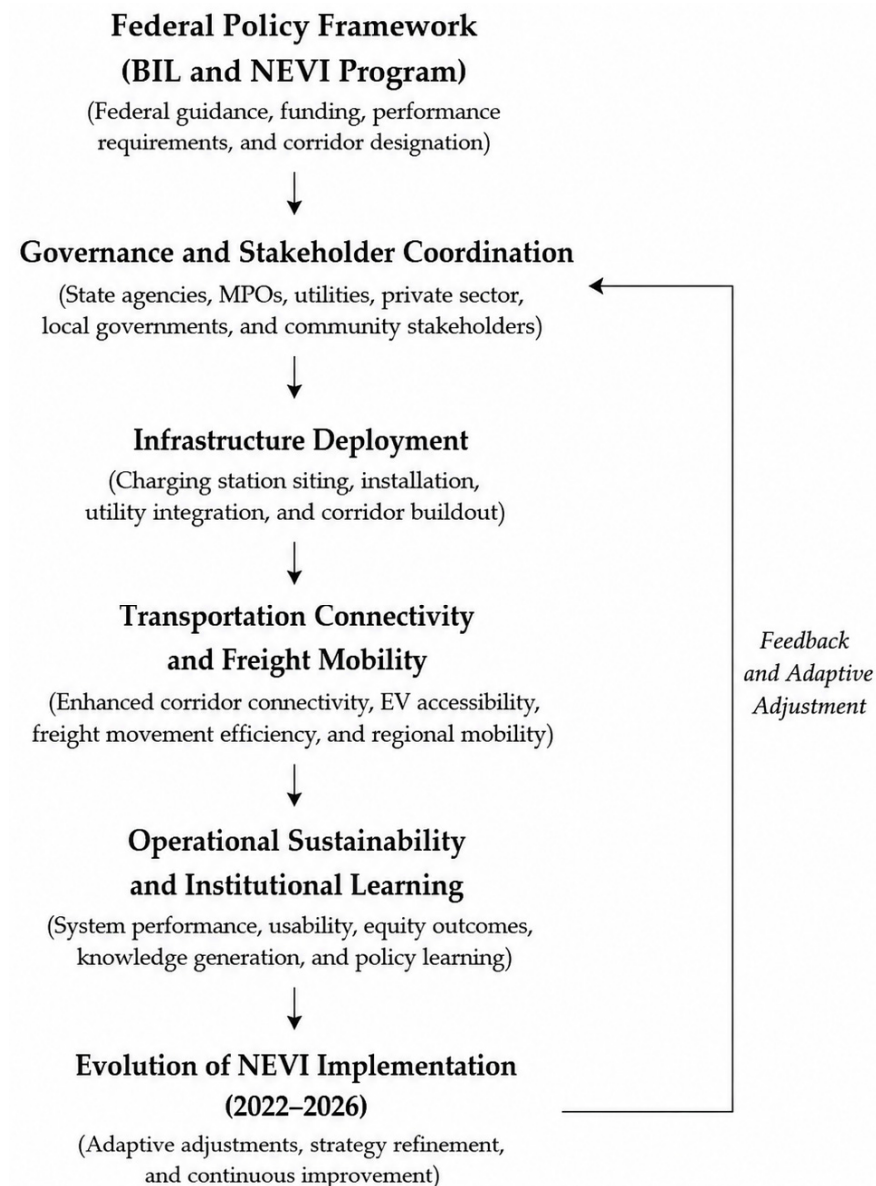


Figure 1. Conceptual framework for examining the evolution of NEVI implementation across the East North Central states.

3. Method

This study employs a qualitative comparative longitudinal research design to examine the evolution of NEVI implementation across the East North Central states between 2022 and 2026. By analyzing state NEVI plans, implementation updates, and supporting transportation documents, the study investigates how governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation evolved during the implementation period. This chapter describes the research design, case selection, data sources, data collection procedures, analytical approach, and interpretive framework used to guide the analysis.

3.1. Research Design

This study employed a qualitative comparative longitudinal research design to examine the evolution of NEVI implementation across the East North Central states between 2022 and 2026. Consistent with a systems perspective, the study investigates transportation electrification as a sustainability transition process involving interactions among governance

structures, infrastructure systems, mobility networks, freight systems, and institutional actors. Qualitative research is particularly well suited for examining implementation evolution, institutional adaptation, and complex governance processes operating within real-world policy environments [45,46].

A comparative longitudinal document analysis approach was used to investigate changes in implementation strategies over time. Longitudinal analysis enables researchers to examine how policies, priorities, and implementation activities evolve across multiple years, while comparative analysis helps identify similarities and differences among cases operating under a shared policy framework [47,48].

The study focused on five states in the East North Central region—Illinois, Indiana, Michigan, Ohio, and Wisconsin—to assess the evolution of governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation under the NEVI program. This approach provides a systematic framework for examining implementation patterns and regional variation across states during the 2022–2026 implementation period [49].

3.2. Geographic Scope and Case Selection

This study focuses on the five states comprising the East North Central division of the U.S. Midwest region: Illinois, Indiana, Michigan, Ohio, and Wisconsin. These states were selected because they operate under the same federal NEVI framework while exhibiting distinct transportation, geographic, and implementation characteristics. Examining multiple states within a shared policy environment provides an opportunity to evaluate similarities and differences in implementation strategies and outcomes [50].

The East North Central region represents a strategically important transportation network within the United States. The region is connected through major interstate corridors, including I-90, I-94, I-80, I-70, I-65, and I-75, which support significant passenger travel, freight movement, and interstate commerce. Consequently, the region provides an appropriate setting for examining transportation connectivity, corridor development, and EV infrastructure deployment under the NEVI program [12,39].

In addition, the selected states play a critical role in regional mobility and freight transportation due to their extensive highway networks, manufacturing activity, and logistics infrastructure. Their shared participation in the NEVI program and strategic importance in transportation make them suitable cases for investigating the evolution of governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation between 2022 and 2026.

3.3. Data Sources

This study used multiple document sources to examine the evolution of NEVI implementation across the East North Central states from 2022 to 2026. Data were drawn from federal, state, and publicly available transportation infrastructure sources to provide a comprehensive understanding of infrastructure deployment, transportation connectivity, freight mobility, and institutional adaptation. As summarized in Table 1, the study incorporated original NEVI plans, implementation updates, federal transportation reports, state transportation documents, and public infrastructure datasets to support a comparative longitudinal analysis. The document collection included official state NEVI plans published in 2022 together with annual implementation updates released between 2023 and 2025. References to 2026 throughout this study correspond to planned implementation activities and targets presented in the most recent publicly available state annual updates rather than completed implementation outcomes.

Table 1. Data collection sources.

Source Type	Description	Examples
NEVI Plans	Original state implementation plans submitted under the NEVI program	2022 State NEVI Plans
NEVI Updates	Revised plans, annual reports, and implementation updates	2023–2026 NEVI Updates
FHWA Reports	Federal transportation and corridor-related documents	AFC Designations, FHWA Guidance
State DOT Documents	State-level implementation and progress reports	Deployment Updates, Progress Reports
Federal Documents	Federal legislation and program guidance	Bipartisan Infrastructure Law (BIL), NEVI Guidance
Public Infrastructure Data	Publicly available EV infrastructure information	Charging Deployment Data, Corridor Status Data

As shown in Table 1, the selected data sources provided complementary perspectives on policy implementation, infrastructure development, corridor planning, and transportation system performance. The use of multiple document sources enhanced the robustness of the analysis through document triangulation and enabled cross-state comparisons among Illinois, Indiana, Michigan, Ohio, and Wisconsin during the 2022–2026 implementation period. Only official federal and state government documents were included in the analysis to ensure the authenticity, consistency, and reliability of the data. Documents from unofficial sources, news media, commercial websites, or opinion-based publications were excluded. The use of official publicly available documents enhanced the credibility of the findings while supporting transparent and replicable qualitative analysis.

3.4. Data Collection Procedures

The data were collected through a systematic review of publicly available documents related to NEVI implementation between 2022 and 2026. Document retrieval focused on official sources to ensure the accuracy, consistency, and reliability of the collected information [49]. Documents were included if they were published between 2022 and 2025 and comprised the original 2022 NEVI plans together with subsequent annual implementation updates. Throughout this study, 2026 refers to planned implementation targets described in the latest publicly available annual updates rather than completed implementation activities. Duplicate documents and materials unrelated to NEVI implementation were excluded from the study.

The primary sources included state DOT websites, the FHWA database, NEVI annual updates, AFC documentation, and other transportation-related reports. These sources provided information regarding infrastructure deployment, corridor development, implementation progress, governance activities, and transportation connectivity across the selected states [12,39].

The data collection period covered documents published between 2022 and 2026, enabling the examination of implementation changes over time. This timeframe aligned with the initial implementation phase of the NEVI program and provided a basis for conducting a comparative longitudinal analysis across Illinois, Indiana, Michigan, Ohio, and Wisconsin [51]. The inclusion of annual implementation updates published between 2023 and 2025 enabled the study to examine the progressive evolution of implementation strategies throughout the NEVI program rather than relying solely on comparisons between the initial 2022 plans and the most recent updates.

3.5. Data Analysis

The collected documents were analyzed using a qualitative thematic analysis approach supported by NVivo 14 software (Lumivero, Denver, CO, USA). The analysis followed a systematic multi-stage coding process to identify patterns, relationships, and implementation trends across the selected states [48,52].

The first stage involved document familiarization, during which all documents were reviewed to gain an overall understanding of NEVI implementation activities, policies, and infrastructure developments. The second stage consisted of open coding, where meaningful concepts and implementation-related information were identified and assigned initial codes. The third stage involved axial coding to group related codes into broader categories and identify relationships among emerging concepts [53,54].

NVivo 14 software (Lumivero, Denver, CO, USA) was used solely as a qualitative data management and coding support tool to facilitate document organization, code management, and thematic retrieval. All coding decisions, category development, theme refinement, interpretation, and cross-state comparisons were conducted by the author to ensure analytical consistency, transparency, and methodological rigor throughout the study.

The fourth stage focused on theme development, whereby categories were refined into overarching themes reflecting the evolution of NEVI implementation. Finally, a cross-state comparative analysis was conducted to identify similarities and differences among Illinois, Indiana, Michigan, Ohio, and Wisconsin regarding governance evolution, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation. This analytical process provided a structured framework for examining implementation patterns across the East North Central region [52,55].

Beyond identifying implementation patterns, the analytical process examined relationships among governance, infrastructure, mobility, freight, operational sustainability, and institutional adaptation dimensions. This systems-oriented approach enabled the study to investigate how interactions among multiple subsystems contributed to the evolution of transportation electrification across the selected states.

3.6. Analytical Dimensions

The analysis was guided by six analytical dimensions derived from the literature review and the study's objectives. These dimensions provided a structured framework for organizing the coding process and evaluating the evolution of NEVI implementation across the East North Central states. The dimensions were selected to capture key aspects of transportation electrification, infrastructure development, transportation connectivity, and institutional change identified in previous studies.

The six analytical dimensions included: (1) Governance Evolution, which examined stakeholder coordination, partnerships, and implementation strategies; (2) Infrastructure Deployment Evolution, which focused on charging infrastructure expansion and corridor development; (3) Transportation Connectivity Evolution, which assessed regional mobility and interstate travel support; (4) Operational Sustainability Evolution, which evaluated reliability, resilience, maintenance, and interoperability considerations; (5) Freight Mobility Evolution, which examined freight transportation, logistics networks, and corridor electrification; and (6) Institutional Adaptation Evolution, which explored policy learning, organizational change, and implementation adjustments over time. These analytical dimensions served as the foundation for the thematic analysis and were subsequently used to organize the results and discussion sections of the study. As summarized in Table 2, the qualitative coding framework illustrates the sequential stages of the analytical process, from document familiarization and coding to cross-state comparison and theory-guided interpretation. Although presented as distinct analytical dimensions, these categories were examined as interconnected components of a broader transportation electrification initiative. The analysis therefore considered both individual dimensions and the relationships among them as implementation evolved between 2022 and 2026.

Table 2. Qualitative coding framework.

Coding Stage	Purpose	Output
Document Familiarization	Review documents	Initial understanding
Open Coding	Identify concepts	Initial codes
Axial Coding	Organize related codes	Categories
Theme Development	Generate themes	Six analytical dimensions
Cross-State Comparison	Compare implementation	Comparative findings
Theory-Guided Interpretation	Interpret findings	Final results

3.7. Trustworthiness and Validation

Several strategies were employed to enhance the study's trustworthiness. First, document triangulation was applied by collecting and analyzing information from multiple sources, including NEVI plans, implementation updates, FHWA reports, state DOT documents, federal guidance, and public infrastructure datasets. The use of multiple data sources helped improve the comprehensiveness and credibility of the findings [49].

Second, consistency checks were conducted throughout the coding and analysis process to ensure that similar concepts and themes were interpreted consistently across documents. The coding structure was reviewed and refined iteratively during the analysis to maintain coherence among the emerging themes [52]. Because the study was conducted by a single researcher, formal inter-coder reliability was not applicable. Instead, analytical reliability was strengthened through iterative coding, repeated document review, document triangulation, continuous refinement of the coding framework, and consistency checks throughout the analytical process.

Finally, cross-state comparison was used to validate implementation patterns and identify similarities and differences among Illinois, Indiana, Michigan, Ohio, and Wisconsin. Comparing findings across multiple states operating under the same federal framework strengthened the robustness of the analysis and supported the identification of regional implementation trends [55].

3.8. Theoretical Lens

This study is guided by Sustainability Transition Theory, which views large-scale technological change as a socio-technical process involving interactions among technology, policy, institutions, infrastructure, and societal actors [40]. The theory has been widely used to examine transitions toward more sustainable transportation and energy systems, including the adoption of EV technologies and supporting infrastructure.

Within the context of transportation electrification, Sustainability Transition Theory provides a useful lens for understanding how EV charging infrastructure evolves through coordinated actions among federal agencies, state governments, utilities, transportation organizations, and private-sector stakeholders. The theory recognizes that successful transitions require not only technological innovation but also institutional adaptation and policy support [56].

Accordingly, Sustainability Transition Theory was used to interpret the evolution of NEVI implementation across the East North Central states between 2022 and 2026. The theory supported the examination of infrastructure deployment, transportation connectivity, governance evolution, freight mobility, operational sustainability, and institutional adaptation as interconnected components of a broader transportation transition.

3.9. Interpretive Framework

In addition to Sustainability Transition Theory, this study employed Adaptive Governance as an interpretive framework to understand how states responded to evolving transportation electrification challenges during NEVI implementation. Adaptive Governance emphasizes flexibility, collaboration, learning, and institutional responsiveness when addressing complex policy and infrastructure transitions [41,42]. The framework is particularly relevant to transportation electrification because implementation occurs within dynamic environments characterized by technological change, evolving stakeholder needs, infrastructure expansion, regulatory adjustments, and uncertainty regarding future transportation demands.

Adaptive Governance was especially useful for interpreting policy learning, institutional adaptation, stakeholder collaboration, and implementation evolution across the East North Central states. As transportation electrification initiatives progressed between 2022 and 2026, state agencies, utilities, transportation organizations, and private-sector stakeholders continuously adjusted strategies, priorities, and implementation approaches in response to emerging challenges and changing conditions. These adaptive responses reflected ongoing efforts to improve infrastructure deployment, strengthen transportation connectivity, address operational concerns, and enhance coordination among participating organizations.

Accordingly, Adaptive Governance was used to examine how states modified planning processes, strengthened collaborative relationships, refined implementation strategies, and responded to emerging transportation electrification priorities throughout the NEVI deployment period. The framework also supported the interpretation of differences in implementation approaches, institutional adaptation, and evolving governance practices across the selected states. By emphasizing learning, flexibility, collaboration, and adaptation, Adaptive Governance provided a valuable interpretive perspective for understanding the evolution of transportation electrification as a dynamic sustainability transition process. The theoretical perspectives were not used to generate the initial codes. Instead, coding was conducted inductively through open and axial coding, after which Sustainability Transition Theory and Adaptive Governance were applied as interpretive lenses to explain the relationships among the identified themes and to understand how governance, infrastructure development, and institutional adaptation evolved during NEVI implementation [44,57].

3.10. Research Process Framework

Figure 2 illustrates the systems-oriented research process employed in this study. The workflow begins with the collection and organization of official documents published between 2022 and 2026, followed by qualitative analysis using NVivo 14 (Lumivero, Denver, CO, USA). The analytical process consists of document familiarization, open coding, axial coding, and theme development, after which the identified themes are organized into six analytical dimensions and compared across the five East North Central states. Finally, the findings are interpreted using Sustainability Transition Theory and Adaptive Governance to explain the evolution of NEVI implementation between 2022 and 2026. This sequential framework demonstrates how documentary evidence was systematically collected, coded, compared, and interpreted to produce theory-informed findings through a qualitative comparative longitudinal analysis.

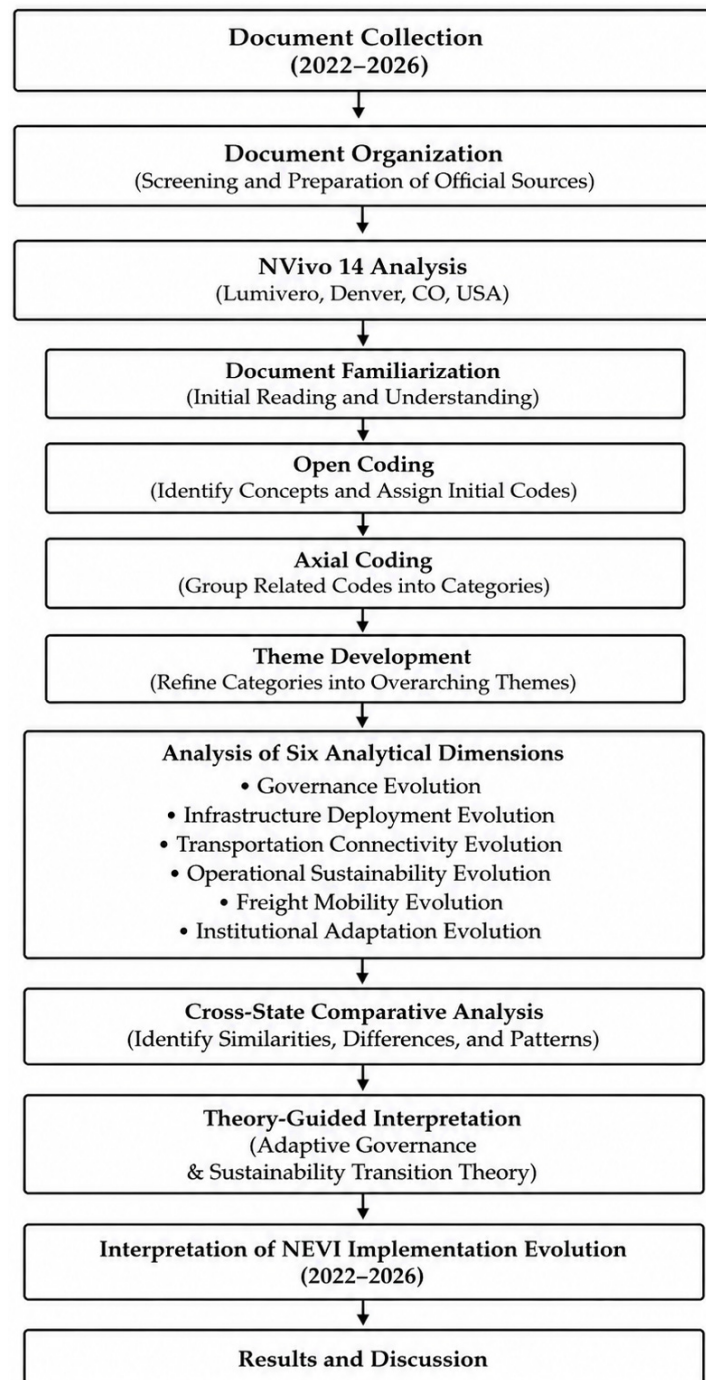


Figure 2. Systems-oriented research process framework.

4. Results

This section presents the findings from the comparative longitudinal analysis of NEVI implementation across Illinois, Indiana, Michigan, Ohio, and Wisconsin between 2022 and 2026. The results highlight changes in governance structures, infrastructure deployment strategies, transportation connectivity priorities, freight mobility considerations, operational sustainability practices, and institutional adaptation efforts during the implementation period.

4.1. Governance and Infrastructure Deployment Evolution

The analysis revealed that all five states adopted collaborative governance structures to support NEVI implementation. State DOTs served as the primary coordinating agencies

while working with utilities, MPOs, and private-sector stakeholders. As shown in Table 3, governance activities evolved from planning and stakeholder engagement in 2022 toward infrastructure deployment and implementation management by 2026.

Table 3. Governance and infrastructure deployment evolution (2022–2026).

State	2022 Focus	2026 Evolution
Illinois	Interagency coordination and statewide corridor buildout	Expanded implementation and policy support
Indiana	AFC completion and statewide corridor coverage	Increased freight and utility integration
Michigan	Multi-agency coordination and border connectivity	Expanded deployment and resilience planning
Ohio	Corridor deployment and statewide charging accessibility	Enhanced workforce and implementation activities
Wisconsin	Corridor readiness and network expansion	Increased policy and infrastructure support

Infrastructure deployment efforts were primarily focused on designated AFCs. All five states prioritized developing NEVI-compliant charging networks along major inter-state corridors before expanding investments to other transportation routes. Although implementation approaches varied, the states shared a common objective of establishing reliable, accessible charging infrastructure to support long-distance EV travel.

Document analysis indicated clear differences in implementation priorities among the five states. Illinois emphasized statewide policy coordination and implementation support, whereas Indiana increasingly integrated freight planning and utility coordination into deployment activities. Michigan expanded cross-border connectivity and infrastructure resilience initiatives, while Ohio strengthened workforce development alongside corridor deployment. Wisconsin focused primarily on expanding corridor readiness and supporting long-term policy implementation. These differences reflected variations in institutional capacity, transportation priorities, freight activity, and existing infrastructure networks. These findings suggest that stronger institutional coordination facilitated more comprehensive implementation strategies by improving stakeholder collaboration, resource allocation, and implementation efficiency.

The findings suggest that governance and infrastructure deployment evolved as inter-dependent components of the transportation electrification initiative. States that expanded stakeholder coordination and interagency collaboration also demonstrated more advanced infrastructure deployment activities, indicating that governance capacity influenced implementation progress. This relationship highlights the importance of governance structures in shaping infrastructure outcomes and illustrates how interactions between institutional and technical subsystems contributed to implementation evolution across the region.

4.2. Transportation Connectivity and Freight Mobility Evolution

Transportation connectivity emerged as a central priority across all five states. The selected states are linked by major interstate corridors, including I-90, I-94, I-80, I-70, I-65, and I-75, which play a significant role in regional mobility and interstate travel. Consequently, NEVI implementation strategies focused on reducing charging gaps and improving corridor continuity.

Freight mobility became increasingly important between 2022 and 2026. While initial plans primarily emphasized passenger-vehicle charging, subsequent implementation activities showed greater consideration for commercial transportation, logistics networks, and future truck electrification needs. This trend was particularly evident in states with substantial freight activity and manufacturing sectors.

Document analysis further indicated that the five states differed in the extent to which freight transportation was integrated into NEVI implementation. Indiana and Michigan demonstrated stronger consideration of freight corridors because of their extensive logis-

tics and manufacturing activities, whereas Illinois and Ohio placed greater emphasis on statewide corridor accessibility. Wisconsin adopted a more gradual approach reflecting regional transportation priorities and implementation capacity.

Table 4 demonstrates that although implementation approaches differed among the five states, all states emphasized interagency coordination and AFC-focused infrastructure deployment. Indiana and Michigan exhibited particularly strong coordination among transportation, utility, and economic development organizations, while Illinois and Ohio demonstrated significant progress in corridor-based charging deployment.

Table 4. Transportation connectivity and freight mobility evolution.

State	AFC Strategy	Freight Mobility Focus
Illinois	Interstate electrification	Moderate
Indiana	Full interstate coverage	High
Michigan	Border and corridor connectivity	High
Ohio	Statewide AFC coverage	Moderate
Wisconsin	Regional corridor development	Moderate

Although all five states prioritized Alternative Fuel Corridor deployment, differences in corridor coverage, freight intensity, and implementation priorities resulted in varying implementation trajectories. These findings indicate that transportation connectivity and freight mobility evolved according to each state's economic structure, geographic characteristics, and transportation demand.

The results further indicate that transportation connectivity and freight mobility evolved as interconnected subsystems rather than independent implementation priorities. As charging networks expanded along major interstate corridors, states increasingly recognized the importance of supporting both passenger and commercial transportation needs. This pattern suggests that infrastructure investments generated broader system-level effects by simultaneously enhancing regional mobility, freight movement, and corridor continuity.

4.3. Operational Sustainability and Institutional Adaptation Evolution

The findings indicate that operational sustainability became increasingly important as implementation progressed. All five states incorporated strategies related to operations and maintenance, reliability, resilience, data management, interoperability, and cybersecurity. These considerations reflected a shift from infrastructure deployment alone toward long-term system performance and operational continuity.

Institutional adaptation was also evident throughout the implementation period. State agencies adjusted implementation priorities, refined deployment strategies, strengthened stakeholder collaboration, and incorporated lessons learned from earlier implementation phases. These adaptive processes contributed to the continued evolution of NEVI implementation across the region.

Table 5 indicates that all five states incorporated long-term operational considerations into their implementation strategies. The findings further reveal evidence of institutional adaptation through policy learning, implementation adjustments, and expanded stakeholder coordination efforts.

The evolution of operational sustainability and institutional adaptation demonstrates characteristics commonly associated with adaptive governance process. As implementation progressed, state agencies incorporated lessons learned, refined deployment strategies, and adjusted operational priorities in response to emerging challenges. These adaptive responses indicate that transportation electrification evolved through continuous learning and institutional adjustment rather than through a fixed implementation process.

Table 5. Operational sustainability and institutional adaptation evolution.

State	Sustainability Measures	Institutional Adaptation
Illinois	Reliability, cybersecurity	High
Indiana	O&M, resilience	High
Michigan	Workforce and resilience	High
Ohio	Workforce and maintenance	High
Wisconsin	Policy adaptation	Moderate

The reviewed implementation documents also identified several operational challenges, including maintenance planning, interoperability, long-term funding requirements, utility coordination, and evolving cybersecurity considerations. Although states demonstrated increasing institutional adaptation, the pace and scope of these adjustments differed according to organizational capacity and implementation experience.

4.4. Cross-State Comparative Findings

Despite differences in implementation approaches, several common patterns emerged across the East North Central states. First, all states prioritized AFC deployment as the foundation of their NEVI implementation strategies. Second, transportation connectivity remained a dominant objective throughout the implementation period. Third, freight mobility considerations became increasingly integrated into infrastructure planning. Finally, operational sustainability and institutional adaptation evolved as implementation activities matured.

Collectively, the findings suggest that NEVI implementation in the East North Central region evolved beyond infrastructure deployment toward a broader transportation systems approach emphasizing connectivity, reliability, freight mobility, and adaptive governance.

As shown in Table 6, all five states prioritized AFC deployment, transportation connectivity, and collaborative governance. Furthermore, freight mobility, operational sustainability, and institutional adaptation became increasingly prominent as implementation activities matured. Collectively, these findings suggest that NEVI implementation evolved beyond infrastructure deployment toward a broader transportation systems approach emphasizing connectivity, resilience, and adaptive governance.

Table 6. Cross-state comparative findings.

Dimension	Common Pattern Across States
Governance	Strong interagency collaboration
Infrastructure Deployment	AFC-first implementation strategy
Transportation Connectivity	Interstate corridor prioritization
Freight Mobility	Increasing freight electrification consideration
Operational Sustainability	Growing focus on reliability and resilience
Institutional Adaptation	Continuous policy and implementation adjustments

The comparative analysis demonstrates that although all five states operated under a common federal policy framework, implementation trajectories differed according to governance capacity, institutional coordination, transportation priorities, freight activity, and regional infrastructure needs. These differences influenced the pace at which implementation evolved and the emphasis placed on infrastructure deployment, operational sustainability, and institutional learning. Collectively, these findings indicate that successful implementation depended not only on federal funding but also on each state's capacity to coordinate stakeholders, adapt implementation strategies, and respond to changing transportation conditions throughout the implementation period.

5. Discussion

This section interprets the findings through the lenses of Sustainability Transition Theory and Adaptive Governance. The discussion focuses on regional transportation electrification, governance adaptation, and transportation system implications arising from NEVI implementation across the East North Central states between 2022 and 2026.

5.1. Transportation Electrification as a Sustainability Transition Process

The findings indicate that NEVI implementation evolved beyond charging infrastructure deployment toward a broader transportation systems approach. This transition occurred because coordinated policy support, institutional collaboration, and infrastructure investment reinforced one another throughout implementation. Consistent with Sustainability Transition Theory, transportation electrification therefore evolved through interactions among governance, infrastructure, mobility, freight, and institutional adaptation rather than through infrastructure deployment alone.

The results further demonstrate that transportation connectivity became a central implementation objective throughout the region. Major interstate corridors, including I-90, I-94, I-80, I-70, I-65, and I-75, served as the foundation for charging infrastructure deployment strategies. This finding is consistent with previous studies highlighting the importance of corridor-based charging infrastructure in reducing range anxiety and supporting long-distance EV travel [3,10]. However, unlike earlier studies that primarily focused on charging accessibility or EV adoption outcomes, the present study demonstrates how transportation connectivity became an implementation objective in itself during the evolution of NEVI deployment.

As summarized in Table 7, the implementation trajectory across the East North Central states reflects a transition from infrastructure planning toward integrated transportation system development. The findings therefore extend previous transportation electrification research by demonstrating how corridor deployment, accessibility, and regional mobility evolved simultaneously during implementation.

Table 7. Evolution of NEVI implementation across the East North Central states.

Dimension	Initial Phase (2022)	Evolution Phase (2026)
Governance	Planning and stakeholder coordination	Institutional adaptation and expanded partnerships
Infrastructure Deployment	AFC identification and planning	Corridor deployment and network expansion
Transportation Connectivity	Accessibility planning	Regional mobility and corridor continuity
Freight Mobility	Limited consideration	Increasing integration into deployment strategies
Operational Sustainability	Infrastructure planning	Reliability, resilience, and maintenance planning
Institutional Adaptation	Program establishment	Policy learning and implementation refinement

Table 7 illustrates that NEVI implementation evolved from a corridor planning initiative into a broader transportation electrification strategy encompassing mobility, accessibility, operational sustainability, and governance adaptation.

5.2. Adaptive Governance and Institutional Learning

The findings reveal substantial governance evolution throughout the implementation period. State DOTs, utilities, MPOs, and regional stakeholders increasingly collaborated to address emerging implementation challenges and opportunities. These findings align with Adaptive Governance theory, which emphasizes institutional flexibility, stakeholder collaboration, and policy learning during complex socio-technical transitions [42].

Unlike many traditional transportation infrastructure programs, NEVI implementation required continuous coordination among federal, state, utility, and private-sector actors. As implementation progressed, states adjusted deployment priorities, refined

planning approaches, strengthened partnerships, and incorporated lessons learned from earlier implementation phases. Similar observations have been reported in sustainability transition research, suggesting that infrastructure transitions depend heavily on adaptive institutional arrangements that can respond to changing conditions [41,56]. Nevertheless, implementation documents also revealed continuing challenges, including utility coordination, procurement procedures, interoperability requirements, and differences in institutional capacity among states. These challenges illustrate that adaptive governance does not eliminate implementation barriers but instead provides mechanisms through which organizations respond to changing conditions over time.

The findings also support previous research emphasizing the importance of collaborative governance in transportation electrification. However, this study extends existing knowledge by demonstrating how governance adaptation evolved over time within a common federal framework, resulting in different implementation pathways across states. Consequently, the results highlight the importance of institutional learning as a critical component of transportation electrification implementation. The findings further indicate that governance adaptation was closely associated with changes in infrastructure deployment, transportation connectivity, freight mobility, and operational sustainability. As implementation progressed, adjustments in one implementation dimension often influenced developments in others, reflecting the adaptive and iterative nature of NEVI implementation under a shared federal policy framework.

5.3. Implications for Transportation Connectivity and Freight Mobility

The findings collectively suggest that transportation electrification in the East North Central region evolved as a complex adaptive sustainability transition process characterized by continuous learning, collaboration, institutional adjustment, and interactions among governance, infrastructure deployment, transportation connectivity, freight mobility, and institutional adaptation. As implementation matured, changes within one subsystem frequently influenced developments in others, creating feedback relationships that shaped implementation outcomes across the region [58].

The findings further suggest that transportation connectivity and freight mobility functioned as interconnected subsystems within the broader transportation electrification initiative. As charging infrastructure expanded along major interstate corridors, improvements in regional mobility also created opportunities for future freight electrification and logistics integration. This pattern demonstrates how infrastructure investments can generate system-wide effects that extend beyond their original implementation objectives. These system-wide effects occurred because investments in charging infrastructure encouraged greater coordination among transportation agencies, utilities, and regional planning organizations, thereby strengthening both passenger mobility and freight transportation planning.

Furthermore, the results suggest that future transportation planning initiatives should integrate freight mobility considerations into transportation electrification strategies from the earliest stages of implementation. While previous studies have often examined passenger and freight transportation separately, the findings indicate that both dimensions are increasingly interconnected in transportation electrification planning. Therefore, transportation agencies may benefit from adopting more integrated planning approaches that simultaneously address passenger mobility, freight transportation, infrastructure resilience, and regional connectivity.

5.4. Transportation Electrification as an Adaptive Governance Process

The findings demonstrate that transportation electrification evolved through continuous learning, institutional adaptation, and stakeholder collaboration throughout NEVI

implementation. Sustainability Transition Theory explains the broader evolution of transportation electrification, whereas Adaptive Governance explains how states adjusted implementation strategies in response to changing institutional, technological, and operational conditions. Together, these complementary perspectives provide a useful framework for understanding the evolution of NEVI implementation across the East North Central states.

6. Conclusions

6.1. Summary of Findings

This study conducted a comparative longitudinal analysis of NEVI implementation across Illinois, Indiana, Michigan, Ohio, and Wisconsin between 2022 and 2026. The findings revealed that NEVI implementation evolved substantially throughout the implementation period, extending beyond charging infrastructure deployment toward a broader transportation systems approach. This evolution occurred through continuous interactions among governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation throughout the implementation period. While all five states initially focused on AFC development and charging accessibility, implementation activities increasingly emphasized transportation connectivity, freight mobility, operational sustainability, and institutional adaptation.

The results further demonstrated that transportation connectivity remained a central implementation objective across the East North Central region. Major interstate corridors, including I-90, I-94, I-80, I-70, I-65, and I-75, served as the foundation for infrastructure deployment strategies, helping improve regional mobility and corridor continuity. At the same time, freight mobility considerations became increasingly integrated into implementation planning as states recognized the importance of supporting commercial transportation and logistics networks within a rapidly evolving transportation environment.

In addition, the findings highlighted the growing importance of collaborative governance and institutional learning during implementation. State DOTs, utilities, MPOs, and private-sector stakeholders played critical roles in supporting infrastructure deployment, addressing operational challenges, and refining implementation strategies. Furthermore, operational sustainability considerations, including reliability, resilience, maintenance, interoperability, and cybersecurity, became more prominent as implementation activities matured across the region. This evolution occurred through continuous interactions among governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation throughout the implementation period.

6.2. Theoretical and Practical Contributions

This study contributes to the transportation electrification literature by providing one of the first comparative longitudinal examinations of NEVI implementation across the East North Central states. Unlike previous studies that primarily focused on EV adoption, charging infrastructure deployment, or transportation accessibility, this research examined how governance, infrastructure deployment, transportation connectivity, freight mobility, operational sustainability, and institutional adaptation evolved simultaneously under a shared federal policy framework.

From a theoretical perspective, the findings support Sustainability Transition Theory by demonstrating that transportation electrification involves interconnected changes across infrastructure systems, institutions, governance structures, and transportation networks. The study also extends Adaptive Governance research by illustrating how policy learning, stakeholder collaboration, and institutional adaptation shaped implementation

evolution during the early phases of NEVI deployment. More broadly, the findings contribute to systems research by demonstrating how transportation electrification can be understood as a complex adaptive sustainability transition process in which governance, infrastructure, mobility, freight, and institutional subsystems interact and co-evolve over time. By integrating Sustainability Transition Theory and Adaptive Governance within a comparative longitudinal framework, the study provides a more comprehensive explanation of how transportation electrification implementation evolves under a shared federal policy environment.

From a practical perspective, the findings provide insights for transportation agencies, policymakers, utilities, and regional planning organizations seeking to implement transportation electrification initiatives. The results suggest that successful implementation requires not only charging infrastructure deployment but also sustained collaboration, transportation connectivity planning, freight mobility integration, and long-term operational sustainability considerations.

6.3. Limitations and Future Research

Several limitations should be acknowledged. First, the study focused exclusively on the five East North Central states, which may limit the generalizability of the findings to other U.S. regions. Second, the analysis relied primarily on publicly available planning documents, implementation updates, and transportation reports rather than direct stakeholder interviews. Third, the study examined implementation activities during the 2022–2026 period and therefore reflects the early stages of NEVI deployment.

Future research could expand this comparative longitudinal framework to other U.S. Census divisions to examine how transportation electrification evolves under different geographic, economic, and institutional conditions. Additional studies may incorporate quantitative indicators of charging infrastructure deployment, transportation accessibility, freight activity, and EV adoption to complement qualitative findings. Extending the analysis beyond 2026 would also provide valuable insights into the long-term evolution of governance, infrastructure systems, institutional adaptation, and sustainability transitions associated with the NEVI program.

Ultimately, the findings indicate that transportation electrification should be understood as a complex adaptive sustainability transition process rather than solely as a charging infrastructure deployment program. The evolution of NEVI implementation across the East North Central states demonstrates how governance structures, infrastructure systems, mobility networks, freight transportation, and institutional adaptation interact to shape implementation outcomes. By adopting a systems perspective, this study provides a broader understanding of transportation electrification implementation and demonstrates that long-term success depends on coordinated governance, institutional learning, adaptive implementation, and the integration of interconnected transportation subsystems.

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References

1. Soltani Mandolakani, F.; Singleton, P.A. Electric Vehicle Charging Infrastructure Deployment: A Discussion of Equity and Justice Theories and Accessibility Measurement. *Transp. Res. Interdiscip. Perspect.* **2024**, *24*, 101072. [\[CrossRef\]](#)
2. Hardman, S.; Chandan, A.; Tal, G.; Turrentine, T. The Effectiveness of Financial Purchase Incentives for Battery Electric Vehicles—A Review of the Evidence. *Renew. Sustain. Energy Rev.* **2017**, *80*, 1100–1111. [\[CrossRef\]](#)
3. Gnann, T.; Funke, S.; Jakobsson, N.; Plötz, P.; Sprei, F.; Bennehag, A. Fast Charging Infrastructure for Electric Vehicles: Today's Situation and Future Needs. *Transp. Res. D Transp. Environ.* **2018**, *62*, 314–329. [\[CrossRef\]](#)
4. Chen, B.; Moore, A.; Jia, B.; Zhang, K.; Cao, M. Equity Considerations in Public Electric Vehicle Charging: A Review. *World Electr. Veh. J.* **2025**, *16*, 553. [\[CrossRef\]](#)
5. Bouraima, M.B.; Więckowski, J. Decision-Support Systems Based Multi-Criteria Decision Analysis for Assessing Electric Vehicle Adoption Policies. *Systems* **2026**, *14*, 551. [\[CrossRef\]](#)
6. Alkhamaiesh, S. Electric Vehicle Infrastructure Deployment in the Mid-Atlantic Region: Comparative Evolution of NEVI Implementation from 2022 to 2026. *World Electr. Veh. J.* **2026**, *17*, 344. [\[CrossRef\]](#)
7. Alkhamaiesh, S. Evolution of NEVI Implementation Across New England States: A Comparative Longitudinal Analysis of EV Infrastructure Governance. *Sustainability* **2026**, *18*, 6230. [\[CrossRef\]](#)
8. Markard, J.; Raven, R.; Truffer, B. Sustainability Transitions: An Emerging Field of Research and Its Prospects. *Res. Policy* **2012**, *41*, 955–967. [\[CrossRef\]](#)
9. Geels, F.W. Technological Transitions as Evolutionary Reconfiguration Processes: A Multi-Level Perspective and a Case-Study. *Res. Policy* **2002**, *31*, 1257–1274. [\[CrossRef\]](#)
10. Jha, S.; Pani, A.; Puppala, H.; Varghese, V.; Unnikrishnan, A. An Equity-Based Approach for Addressing Inequality in Electric Vehicle Charging Infrastructure: Leaving No One behind in Transport Electrification. *Energy Sustain. Dev.* **2025**, *85*, 101643. [\[CrossRef\]](#)
11. Kong, Q.; Fowler, M.; Entchev, E.; Ribberink, H.; McCallum, R. The Role of Charging Infrastructure in Electric Vehicle Implementation within Smart Grids. *Energies* **2018**, *11*, 3362. [\[CrossRef\]](#)
12. Cronin, B. Federal Highway Administration (FHWA) Update. *IEEE Trans. Intell. Transp. Syst.* **2024**, *25*, 54–70. [\[CrossRef\]](#)
13. Federal Highway Administration (FHWA); U.S. Department of Transportation (DOT). *National Electric Vehicle Infrastructure Standards and Requirements*; Federal Highway Administration (FHWA): Washington, DC, USA, 2023.
14. Attari, H.; Tayarani, H. State-Level Implementation of the National Electric Vehicle Infrastructure (NEVI) Program: A Comparative Analysis of California, Texas, and New York. *Transp. Res. Interdiscip. Perspect.* **2025**, *34*, 101717. [\[CrossRef\]](#)
15. Lou, J.; Dule, A.A.; Shen, X.; Hultman, N. Advancing Equity in Electric Vehicle Infrastructure: Assessing Charging Accessibility under the National Electric Vehicle Infrastructure (NEVI) Program. *Energy Res. Soc. Sci.* **2026**, *134*, 104620. [\[CrossRef\]](#)
16. Alkhamaiesh, S. Driving Change: A Comprehensive Analysis of Electric Vehicle Workforce Development in Connecticut State Under the Bipartisan Infrastructure Law. *World Electr. Veh. J.* **2026**, *17*, 298. [\[CrossRef\]](#)
17. Alkhamaiesh, S.; Cavanaugh, P.F. Preparing EV Technicians for the U.S.A Transition to Electric Vehicles through the Implementation of the Bipartisan Infrastructure Law. *Mod. Econ.* **2023**, *14*, 1504–1514. [\[CrossRef\]](#)
18. Ugwu, M.C.; Adewusi, A.O. International EV Policies: A Comparative Review of Strategies in the United States and Nigeria for Promoting Electric Vehicles. *Int. J. Sch. Res. Rev.* **2024**, *4*, 011–023. [\[CrossRef\]](#)
19. Nicholas, M.; Hall, D.; Lutsey, N. *Quantifying the Electric Vehicle Charging Infrastructure Gap Across U.S. Markets*; International Council on Clean Transportation (ICCT): Washington, DC, USA, 2019.
20. Bonges, H.A.; Lusk, A.C. Addressing Electric Vehicle (EV) Sales and Range Anxiety through Parking Layout, Policy and Regulation. *Transp. Res. Part A Policy Pract.* **2016**, *83*, 63–73. [\[CrossRef\]](#)
21. Baumgarte, F.; Kaiser, M.; Keller, R. Policy Support Measures for Widespread Expansion of Fast Charging Infrastructure for Electric Vehicles. *Energy Policy* **2021**, *156*, 112372. [\[CrossRef\]](#)
22. Jenn, A.; Springel, K.; Gopal, A.R. Effectiveness of Electric Vehicle Incentives in the United States. *Energy Policy* **2018**, *119*, 349–356. [\[CrossRef\]](#)
23. Nicholas, M. *Estimating Electric Vehicle Charging Infrastructure Costs Across Major U.S. Metropolitan Areas*; International Council on Clean Transportation (ICCT): Washington, DC, USA, 2019.
24. Hall, D.; Lutsey, N. *Emerging Best Practices for Electric Vehicle Charging Infrastructure* Dale Hall, Nic Lutsey; International Council on Clean Transportation (ICCT): Washington, DC, USA, 2017.
25. Coffman, M.; Bernstein, P.; Wee, S. Electric Vehicles Revisited: A Review of Factors That Affect Adoption. *Transp. Res.* **2017**, *37*, 79–93. [\[CrossRef\]](#)
26. Sovacool, B.K.; Axsen, J.; Kempton, W. The Future Promise of Vehicle-to-Grid (V2G) Integration: A Sociotechnical Review and Research Agenda. *Annu. Rev. Environ. Resour.* **2017**, *42*, 377–406. [\[CrossRef\]](#)
27. Mersky, A.C.; Sprei, F.; Samaras, C.; Qian, Z.S. Effectiveness of Incentives on Electric Vehicle Adoption in Norway. *Transp. Res. D Transp. Environ.* **2016**, *46*, 56–68. [\[CrossRef\]](#)

28. Markard, J. The next Phase of the Energy Transition and Its Implications for Research and Policy. *Nat. Energy* **2018**, *3*, 628–633. [\[CrossRef\]](#)
29. Kivimaa, P.; Laakso, S.; Lonkila, A.; Kaljonen, M. Moving beyond Disruptive Innovation: A Review of Disruption in Sustainability Transitions. *Environ. Innov. Soc. Transit.* **2021**, *38*, 110–126. [\[CrossRef\]](#)
30. Breetz, H.; Mildenerberger, M.; Stokes, L. The Political Logics of Clean Energy Transitions. *Bus. Polit.* **2018**, *20*, 492–522. [\[CrossRef\]](#)
31. Carley, S.; Evans, T.P.; Konisky, D.M. Adaptation, Culture, and the Energy Transition in American Coal Country. *Energy Res. Soc. Sci.* **2018**, *37*, 133–139. [\[CrossRef\]](#)
32. Carley, S.; Konisky, D.M. The Justice and Equity Implications of the Clean Energy Transition. *Nat. Energy* **2020**, *5*, 569–577. [\[CrossRef\]](#)
33. Deka, D. Three Revolutions: Steering Automated, Shared, and Electric Vehicles to a Better Future. *Transp. Rev.* **2019**, *39*, 553–555. [\[CrossRef\]](#)
34. Rempel, D.; Cullen, C.; Matteson Bryan, M.; Vianna Cezar, G. Reliability of Open Public Electric Vehicle Direct Current Fast Chargers. *Hum. Factors J. Hum. Factors Ergon. Soc.* **2024**, *66*, 2528–2538. [\[CrossRef\]](#) [\[PubMed\]](#)
35. Ronanki, D.; Karneddi, H. Electric Vehicle Charging Infrastructure: Review, Cyber Security Considerations, Potential Impacts, Countermeasures, and Future Trends. *IEEE J. Emerg. Sel. Top. Power Electron.* **2024**, *12*, 242–256. [\[CrossRef\]](#)
36. Hesri, A.; Khaleel, M.; Ahmed, A.A.; Nassar, Y. Grid Integration of EVs: Deploying Measures, Standards and Interoperability and Policy. *Int. J. Electr. Eng. Sustain.* **2025**, *3*, 1–18. [\[CrossRef\]](#)
37. Shi, X.; Yao, H.; Liang, Z.; Li, X. An Empirical Study on Fuel Consumption of Commercial Automated Vehicles. *Transp. Res. D Transp. Environ.* **2022**, *106*, 103253. [\[CrossRef\]](#)
38. Sen, B.; Ercan, T.; Tatari, O. Does a Battery-Electric Truck Make a Difference?—Life Cycle Emissions, Costs, and Externality Analysis of Alternative Fuel-Powered Class 8 Heavy-Duty Trucks in the United States. *J. Clean. Prod.* **2017**, *141*, 110–121. [\[CrossRef\]](#)
39. Yang, H.; Fulton, L.; Kendall, A. A Review of Charging Infrastructure Requirements for US Electric Light-Duty Vehicles. *Renew. Sustain. Energy Rev.* **2024**, *200*, 114608. [\[CrossRef\]](#)
40. Geels, F.W. Socio-Technical Transitions to Sustainability: A Review of Criticisms and Elaborations of the Multi-Level Perspective. *Curr. Opin. Environ. Sustain.* **2019**, *39*, 187–201. [\[CrossRef\]](#)
41. Kivimaa, P.; Kern, F. Creative Destruction or Mere Niche Support? Innovation Policy Mixes for Sustainability Transitions. *Res. Policy* **2016**, *45*, 205–217. [\[CrossRef\]](#)
42. Chaffin, B.C.; Gosnell, H.; Cosens, B.A. A Decade of Adaptive Governance Scholarship: Synthesis and Future Directions. *Ecol. Soc.* **2014**, *19*, art56. [\[CrossRef\]](#)
43. Vogel, B.; Henstra, D. Studying Local Climate Adaptation: A Heuristic Research Framework for Comparative Policy Analysis. *Glob. Environ. Change* **2015**, *31*, 110–120. [\[CrossRef\]](#)
44. Dorostkar, E.; Najarsadeghi, M. The Strategic Arbiter: AI-Mediated Game Theory for Sustainable Socio-Technical Transitions in Human Mobility Systems. *Transp. Res. Interdiscip. Perspect.* **2026**, *38*, 102050. [\[CrossRef\]](#)
45. Lewis, S. Qualitative Inquiry and Research Design: Choosing Among Five Approaches. *Health Promot. Pract.* **2015**, *16*, 473–475. [\[CrossRef\]](#)
46. Phelan, S. Case Study Research: Design and Methods. *Eval. Res. Educ.* **2011**, *24*, 221–222. [\[CrossRef\]](#)
47. Audulv, Å.; Hall, E.O.C.; Kneck, Å.; Westergren, T.; Fegran, L.; Pedersen, M.K.; Aagaard, H.; Dam, K.L.; Ludvigsen, M.S. Qualitative Longitudinal Research in Health Research: A Method Study. *BMC Med. Res. Methodol.* **2022**, *22*, 255. [\[CrossRef\]](#) [\[PubMed\]](#)
48. Saldaña, J. *The Coding Manual for Qualitative Researchers*; SAGE Publications: Thousand Oaks, CA, USA, 2021.
49. Bowen, G.A. Document Analysis as a Qualitative Research Method. *Qual. Res. J.* **2009**, *9*, 27–40. [\[CrossRef\]](#)
50. Teegavarapu, S.; Summers, J.D.; Mocko, G.M. Case Study Method for Design Research: A Justification. In *Proceedings of the Volume 4: 20th International Conference on Design Theory and Methodology; Second International Conference on Micro- and Nanosystems*; ASMEDC: New York, NY, USA, 2008; pp. 495–503.
51. Neale, B. *Qualitative Longitudinal Research: Research Methods*; Bloomsbury Academic: London, UK, 2021.
52. Braun, V.; Clarke, V. Reflecting on Reflexive Thematic Analysis. *Qual. Res. Sport Exerc. Health* **2019**, *11*, 589–597. [\[CrossRef\]](#)
53. Jones, D.A. A Review and Critical Analysis of Qualitative Methodologies and Data-Collection Techniques Used for Code-Switching Research. *Am. J. Qual. Res.* **2023**, *7*, 53–72. [\[CrossRef\]](#)
54. Sovacool, B.K.; Axsen, J.; Delina, L.L.; Boudet, H.S.; Rai, V.; Sidortsov, R.; Churchill, S.A.; Jenkins, K.E.H.; Galvin, R. Towards Codes of Practice for Navigating the Academic Peer Review Process. *Energy Res. Soc. Sci.* **2022**, *89*, 102675. [\[CrossRef\]](#)
55. Yin, R.K. *Case Study Research and Applications*; SAGE Publications US: Thousand Oaks, CA, USA, 2017.
56. Markard, J.; Geels, F.W.; Raven, R. Challenges in the Acceleration of Sustainability Transitions. *Environ. Res. Lett.* **2020**, *15*, 081001. [\[CrossRef\]](#)

57. van Uden, M.F.M.; Wamelink, J.W.F.; van Bueren, E.M.; Heurkens, E.W.T.M. Crossovers between Sustainability Transitions Research and Social Practice Theory: A Systematic Literature Review. *Clean. Prod. Lett.* **2024**, *7*, 100083. [[CrossRef](#)]
58. Wood, E.; Rames, C.; Muratori, M.; Raghavan, S.; Melaina, M. *National Plug-In Electric Vehicle Infrastructure Analysis National Plug-In Electric Vehicle Infrastructure Analysis Iii Authors*; U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE): Washington, DC, USA, 2017.

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