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Electric Vehicle Infrastructure Deployment in the Mid-Atlantic Region: Comparative Evolution of NEVI Implementation from 2022 to 2026

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Abstract

The National Electric Vehicle Infrastructure (NEVI) Program is a major federal initiative to expand electric vehicle (EV) charging infrastructure and support transportation electrification in the United States. This study examines the evolution of NEVI implementation across New York, New Jersey, and Pennsylvania between 2022 and 2026. A qualitative comparative longitudinal approach was used to analyze 23 official documents, including NEVI deployment plans, annual implementation updates, Federal Highway Administration guidance, and Joint Office of Energy and Transportation resources. The findings show that implementation evolved beyond compliance with the Alternative Fuel Corridor toward broader transportation electrification, characterized by adaptive governance, infrastructure scalability, and operational resilience. New York demonstrated the most advanced implementation through extensive interagency coordination, infrastructure integration, and long-term planning. New Jersey emphasized metropolitan charging accessibility, adaptive planning, and alignment with statewide zero-emission vehicle objectives. Pennsylvania followed a more gradual implementation trajectory shaped by phased deployment, regional accessibility priorities, and procurement-related challenges. The study demonstrates that implementation trajectories differed despite a common federal framework and contributes to the literature by providing a comparative longitudinal perspective on how governance and institutional adaptation influence large-scale EV infrastructure deployment.

Keywords: electric vehicle infrastructure; transportation electrification; nevi program; adaptive governance; sustainability transition; operational resilience; metropolitan mobility; collaborative governance



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1. Introduction

1.1. Transportation Electrification and the Growth of EV Infrastructure

The global transition toward electric vehicles (EVs) has accelerated due to environmental concerns, climate change mitigation goals, technological advancements, and government transportation electrification policies. The transportation sector remains one of the largest contributors to global greenhouse gas emissions, particularly in the United States, where transportation emissions account for approximately 29% of total greenhouse gas emissions [1,2]. As governments pursue decarbonization strategies and sustainability-oriented transportation systems, EVs have emerged as a central component of long-term climate and energy transition policies [3]. In addition to reducing direct emissions, EV adoption

is increasingly associated with energy security, sustainable mobility, and infrastructure modernization across urban and interstate transportation systems [4].

The continued growth of EV adoption has increased the importance of accessible and reliable charging infrastructure. Previous studies have demonstrated that charging accessibility significantly influences EV adoption confidence and long-distance mobility behavior [5]. Consequently, expanding charging infrastructure has become a fundamental requirement for supporting the continued transition toward sustainable transportation.

1.2. The National Electric Vehicle Infrastructure (NEVI) Program

The Bipartisan Infrastructure Law established the National Electric Vehicle Infrastructure (NEVI) Formula Program to accelerate the deployment of publicly accessible EV charging infrastructure across the United States. The program provides a national implementation framework that combines federal guidance, evaluation planning, and deployment responsibilities to support the expansion of a reliable and interconnected charging network [2]. By encouraging coordinated infrastructure planning while allowing states flexibility in implementation, the program has become a central component of the national transportation electrification strategy [6].

1.3. Mid-Atlantic Transportation Electrification Complexity

Although the NEVI program established a national implementation framework, infrastructure deployment conditions vary substantially across U.S. regions because of differences in transportation density, urbanization, institutional arrangements, utility systems, implementation capacity, and charging demand. The Mid-Atlantic region, comprising New York, New Jersey, and Pennsylvania, is among the most challenging transportation electrification environments in the United States.

The region features dense metropolitan transportation systems, highly interconnected interstate corridors, major freight and commuter mobility networks, and substantial urban charging demand. These conditions pose additional challenges to infrastructure scalability, utility collaboration, interoperability, service reliability, and equitable access to charging across interconnected metropolitan systems [7]. The complexity of transportation electrification in metropolitan environments, therefore, requires coordinated planning, stakeholder collaboration, and long-term infrastructure development to support sustainable mobility objectives.

New York, New Jersey, and Pennsylvania were selected because they represent three of the most strategically important states in the Mid-Atlantic transportation network. Together, they encompass dense interstate highway corridors, large metropolitan areas, high levels of transportation demand, and growing EV markets, making them well-suited to examine the evolution of infrastructure deployment under a common federal framework. Although the states operate under the same NEVI requirements, they differ in governance arrangements, transportation priorities, implementation approaches, and regional planning contexts. These shared characteristics and institutional differences provide an appropriate basis for a comparative longitudinal analysis of how implementation has evolved across complex transportation systems [8].

1.4. Research Gap

Existing studies have substantially improved understanding of transportation electrification by examining EV adoption, charging accessibility, infrastructure planning, workforce development, and transportation sustainability policies [9,10]. More recently, research has also begun to investigate the implementation of the NEVI program at the state level. However, little attention has been given to how implementation evolved across multiple states operating under the same federal policy framework over time. In particular, comparative

longitudinal evidence examining implementation trajectories between 2022 and 2026 remains limited, especially within the highly interconnected metropolitan transportation systems of the Mid-Atlantic region. Consequently, important questions remain regarding how implementation strategies, infrastructure deployment priorities, and institutional responses evolved under shared federal guidance. This study addresses these gaps through a comparative longitudinal analysis of NEVI implementation across New York, New Jersey, and Pennsylvania [1,5].

1.5. Purpose of the Study

The purpose of this study is to compare the evolution of NEVI implementation across Mid-Atlantic states from 2022 to 2026. The study focuses on New York, New Jersey, and Pennsylvania to analyze how implementation evolved across governance coordination, infrastructure deployment, equity and accessibility priorities, operational sustainability, and institutional adaptation within dense metropolitan transportation systems. The study further aims to examine how transportation electrification implementation evolved beyond federally guided infrastructure deployment toward broader sustainability-oriented governance and operational transition processes.

1.6. Research Question

This study is guided by the following research question:

- How did NEVI implementation evolve across Mid-Atlantic states between 2022 and 2026 regarding governance coordination, infrastructure deployment, operational sustainability, and institutional adaptation within dense metropolitan transportation systems?

1.7. Contribution to Existing Knowledge

This study contributes to the literature on transportation electrification and sustainability governance in several important ways. First, it offers one of the few comparative longitudinal analyses of NEVI implementation across Mid-Atlantic states under a shared federal implementation framework. Second, it extends EV infrastructure research by examining the complexity of metropolitan implementation, interstate corridor integration, infrastructure scalability, and operational resilience in highly interconnected transportation systems. Third, it contributes to the adaptive governance and sustainability transition literature by showing how institutional coordination, collaborative governance, and operational adaptation shaped the implementation of transportation electrification across dense regional mobility systems. Finally, it provides practical insights for policymakers, transportation agencies, utilities, metropolitan planning organizations, and infrastructure operators on governance coordination, infrastructure resilience, equitable access to charging, and long-term operational sustainability in large-scale EV charging ecosystems.

2. Literature Review

2.1. Transportation Electrification and EV Infrastructure Expansion

The transition toward transportation electrification has accelerated significantly in recent years as governments worldwide seek to reduce greenhouse gas emissions, improve energy sustainability, and support long-term decarbonization objectives. In the United States, the transportation sector remains one of the largest contributors to carbon emissions, heightening the urgency for policies that promote electric vehicle adoption and expand charging infrastructure networks [11,12]. Electric vehicles have increasingly become a central component of sustainable mobility strategies because they reduce direct vehicle emissions while supporting broader climate and clean energy transition goals [13].

The growth in EV adoption has heightened the importance of accessible, reliable charging infrastructure. Previous studies have emphasized that charging availability directly influences consumer confidence, EV purchasing behavior, and long-term market penetration [14]. Public charging infrastructure, particularly fast-charging systems, plays a critical role in supporting long-distance travel, reducing range anxiety, and enabling large-scale transportation electrification across urban and interstate corridors [11]. Furthermore, the expansion of Alternative Fuel Corridors (AFCs) has become increasingly important for integrating regional mobility and maintaining continuity of interstate EV travel.

Recent research further indicates that infrastructure scalability and operational accessibility are increasingly important as EV markets mature. Urban regions with high population density and strong transportation demand require more sophisticated charging ecosystems to support large-scale vehicle adoption, operational continuity, and grid integration [15]. High-density metropolitan environments also pose additional challenges for charger placement, electrical load management, land availability, and charging accessibility for apartment residents and multifamily housing communities [16]. These urban implementation challenges are particularly relevant in highly populated interstate transportation systems, such as the Mid-Atlantic region.

In addition, interstate mobility and corridor-based transportation systems have become increasingly important in EV infrastructure planning. Fast-charging deployment along major transportation corridors supports regional transportation integration, reliable interstate travel, and continuity of the broader charging network [7]. Studies on EV infrastructure deployment emphasize that transportation electrification requires not only expanding urban charging but also the development of coordinated regional infrastructure systems that support scalable mobility transitions across an interconnected transportation network [17].

Operational sustainability has also emerged as a major implementation concern as charging infrastructure networks continue to expand. Recent literature highlights the growing importance of interoperability, grid resilience, maintenance sustainability, cybersecurity preparedness, and charging up time in large-scale EV charging ecosystems [17,18]. These operational considerations increasingly shape infrastructure planning, particularly in metropolitan and high-demand transportation environments where charging reliability and infrastructure continuity are essential to long-term EV adoption confidence.

Overall, previous studies consistently demonstrate that accessible and reliable charging infrastructure is essential for supporting EV adoption and long-term transportation electrification. However, the literature has primarily focused on infrastructure availability, charging technologies, and consumer adoption, with comparatively less attention given to how infrastructure strategies evolve over time within large-scale federal implementation programs. This limitation highlights the need for comparative longitudinal research examining implementation evolution across different regional contexts.

2.2. The NEVI Program and Federal Transportation Electrification Policy

The Bipartisan Infrastructure Law, formally known as the Infrastructure Investment and Jobs Act, represents one of the largest federal investments in transportation electrification in the United States. The legislation allocated approximately \$7.5 billion to expand EV charging infrastructure through the NEVI Formula Program and other federal charging initiatives [11]. Of this amount, \$5 billion was allocated through the NEVI Formula Program to all 50 states, the District of Columbia, and Puerto Rico between 2022 and 2026, supporting the deployment of publicly accessible fast-charging infrastructure along designated transportation corridors [6].

The program established a shared federal-state implementation framework. Under this framework, the Federal Highway Administration provides national standards and implementation guidance while allowing states flexibility in deployment strategies, procurement approaches, infrastructure prioritization, and implementation planning [7]. To receive federal funding, states are required to submit annual EV Infrastructure Deployment Plans that document implementation progress and future priorities.

The central objective of the program is the development of Alternative Fuel Corridors to support reliable interstate travel through minimum requirements for charger spacing, charging speed, interoperability, uptime, and accessibility [6]. Although these federal requirements establish a consistent national framework, states retain considerable flexibility to adapt implementation strategies according to regional transportation characteristics, institutional capacity, utility coordination, and market readiness. As a result, implementation trajectories have varied across states despite operating under the same federal policy framework.

Although the federal framework set standardized implementation objectives, states retained substantial flexibility to adapt deployment strategies to regional transportation conditions, institutional structures, market readiness, and operational priorities. Recent comparative evidence demonstrates that differences in governance capacity, institutional coordination, and regional priorities have resulted in distinct implementation pathways among states despite operating under the same federal program [7,19]. Previous research showed that states followed different implementation trajectories based on governance coordination, utility partnerships, procurement models, infrastructure maturity, and stakeholder engagement capacity [7]. Some states rapidly advanced corridor deployment and public-private partnerships, while others faced implementation barriers linked to permitting complexity, procurement delays, utility coordination challenges, rural accessibility, and operational scalability [20].

Although existing studies generally agree that the NEVI Program provides a consistent national implementation framework while allowing states flexibility in deployment strategies, most published research has focused primarily on policy design or individual state implementation experiences. Consequently, comparatively little evidence explains how implementation trajectories evolved across multiple states operating under the same federal policy framework over time.

2.3. Governance and Institutional Coordination in EV Infrastructure Deployment

The implementation of electric vehicle charging infrastructure increasingly depends on effective governance systems, institutional coordination, and stakeholder collaboration, rather than on technical infrastructure deployment alone. Recent studies emphasize that transportation electrification requires coordination among transportation agencies, utility providers, metropolitan planning organizations (MPOs), environmental agencies, and private charging operators to support long-term infrastructure scalability and operational continuity [7,21].

Adaptive governance has become increasingly important for EV infrastructure implementation because transportation electrification operates within complex socio-technical systems marked by evolving infrastructure demand, interoperability requirements, and operational coordination challenges [22]. Prior research suggests that adaptive governance supports institutional flexibility, collaborative implementation, and long-term infrastructure transition processes, particularly in highly connected metropolitan transportation systems [23].

Utility coordination also plays a major role in EV infrastructure deployment because charging expansion directly affects grid capacity, operational reliability, and infrastructure

resilience. Studies highlight that utility providers are increasingly contributing to charging integration, electrical load management, operational continuity, and resilient infrastructure planning, particularly in urban transportation regions with high charging demand [18,24].

Metropolitan planning organizations (MPOs) and interstate transportation coordination have become increasingly important components of implementation in dense transportation corridors, such as the Mid-Atlantic region. Regional transportation integration, corridor continuity, and urban mobility planning increasingly require collaboration among neighboring states, regional transportation agencies, and private infrastructure stakeholders [16,24].

Public-private partnerships also support infrastructure financing, charging network expansion, operational scalability, and long-term maintenance sustainability. Recent implementation studies have shown that collaborative partnerships among government agencies, utilities, and private charging operators increasingly influence implementation effectiveness and operational maturity in large-scale transportation electrification systems [7,15].

Overall, previous studies consistently recognize governance coordination as an essential component of EV infrastructure deployment. However, they differ in the aspects of governance considered most influential, with some emphasizing institutional collaboration and stakeholder engagement, while others highlight utility partnerships and regional transportation planning. Consequently, further research is needed to understand how governance arrangements evolve over time under a shared federal implementation framework.

2.4. Equity, Accessibility, and Metropolitan Charging Challenges

Equity and accessibility have become increasingly important considerations in transportation electrification and EV infrastructure deployment. Early EV charging expansion focused on highway corridors and infrastructure availability; however, recent studies emphasize that equitable charging access is essential to support inclusive transportation transitions and long-term EV adoption [16]. Federal initiatives such as Justice40 have further increased attention to underserved communities, disadvantaged populations, and equitable infrastructure investment within transportation electrification programs.

Urban charging inequity has emerged as a significant challenge in densely populated metropolitan regions. Previous research shows that charging infrastructure availability often varies across neighborhoods in terms of income, housing conditions, and urban development patterns, creating charging disparities and unequal EV accessibility [25]. These disparities are particularly important in large metropolitan transportation systems, such as those in the Mid-Atlantic region, where population density, transportation demand, and infrastructure constraints add complexity to implementation.

Multifamily housing and renter accessibility also pose major barriers to equitable EV adoption. Apartment residents and renters frequently face limited access to private charging infrastructure due to parking constraints, property ownership limitations, and insufficient charging installations in residential buildings [16]. As a result, public charging accessibility and the expansion of urban charging networks have become increasingly important for supporting equitable transportation electrification in metropolitan areas.

Recent literature also highlights the emergence of “charging deserts,” where underserved urban communities experience limited charging availability despite growing demand for EVs [15]. These accessibility gaps may slow EV adoption and reinforce transportation inequities if infrastructure deployment primarily favors higher-income or commercially attractive locations. Consequently, transportation agencies and policymakers increasingly emphasize equitable infrastructure planning, affordable access to charging, and broader community-based deployment strategies in NEVI implementation.

Overall, the literature consistently emphasizes the importance of equitable access to charging for supporting inclusive transportation electrification. However, previous studies have primarily examined accessibility from social or geographic perspectives, providing a limited understanding of how equity priorities evolve during implementation or how states balance corridor deployment with metropolitan accessibility and underserved communities over time.

2.5. Operational Sustainability and Infrastructure Resilience

As EV charging infrastructure networks continue to expand, operational sustainability and infrastructure resilience have become increasingly important implementation priorities. Early transportation electrification efforts primarily emphasized charging deployment and corridor coverage; however, recent research highlights that long-term implementation success depends heavily on operational reliability, infrastructure continuity, and system resilience [24]. Growing dependence on public charging systems has shifted policy and operational attention toward maintaining stable, scalable, and resilient charging ecosystems capable of supporting rising EV demand.

Uptime reliability has emerged as one of the most critical operational concerns in the implementation of charging infrastructure. Studies demonstrate that charger downtime, operational failures, and inconsistent charging availability negatively affect user confidence and EV adoption behavior [26]. Consequently, federal NEVI requirements increasingly emphasize uptime performance standards, operational monitoring systems, and maintenance accountability to improve charging reliability across interstate transportation networks.

Cybersecurity and interoperability have also become increasingly important within modern charging ecosystems due to the growing integration of digital payment systems, cloud-based charging management, utility communication networks, and smart-grid technologies. Previous research suggests that EV charging systems are increasingly vulnerable to cybersecurity threats, operational disruptions, and data communication risks if resilience protections and interoperability standards are not adequately integrated into infrastructure planning [18,27]. Recent reviews further emphasize that interoperability standards, smart charging technologies, and coordinated grid integration are becoming essential components of reliable and sustainable charging ecosystems [28]. Interoperability standards also support consistent user accessibility and charging continuity across multiple charging providers and transportation jurisdictions.

Grid resilience and electrical load management further represent major operational challenges within densely populated metropolitan transportation systems. High-demand urban charging environments place increasing pressure on regional electrical infrastructure, particularly during peak demand periods and large-scale fast-charging operations [29]. Metropolitan transportation corridors, such as those in the Mid-Atlantic region, require scalable operational systems capable of supporting large charging loads, infrastructure redundancy, utility coordination, and resilient grid integration to maintain long-term operational continuity.

Preventive maintenance and operational continuity have similarly become central components of sustainable charging infrastructure management. Recent implementation studies emphasize that long-term infrastructure effectiveness depends not only on charger installation but also on continuous monitoring, maintenance planning, operational responsiveness, and infrastructure lifecycle management [30]. These operational requirements are increasingly important within large metropolitan charging systems, where infrastructure downtime may significantly affect transportation accessibility and charging network reliability.

Overall, previous studies agree that operational sustainability has become increasingly important as charging networks expand. Nevertheless, existing research has primarily examined individual operational issues such as interoperability, cybersecurity, or infrastructure resilience independently. Less attention has been paid to how these operational priorities evolve collectively across different implementation stages in large-scale federal infrastructure programs.

2.6. Adaptive Governance and Sustainability Transition

Transportation electrification increasingly represents a broader sustainability transition rather than a purely technological infrastructure expansion. Recent sustainability transition literature emphasizes that large-scale infrastructure transformation requires institutional adaptation, governance evolution, and long-term socio-technical coordination to support sustainable mobility systems [3]. In EV infrastructure implementation, charging networks operate as socio-technical systems that involve interactions among government agencies, utilities, private infrastructure providers, transportation systems, regulatory frameworks, and public users.

Adaptive governance has emerged as an important theoretical lens for understanding how institutions respond to evolving operational conditions, infrastructure challenges, and implementation complexity within sustainability transitions [9]. Previous studies suggest that adaptive governance supports institutional flexibility, collaborative decision-making, policy learning, and long-term implementation responsiveness within complex infrastructure systems [31]. These characteristics are increasingly important in transportation electrification because EV infrastructure systems require continuous adaptation to changing technology standards, operational demands, and mobility patterns.

Collaborative governance also plays a central role in sustainable transportation transitions because EV infrastructure deployment depends on coordination among multiple public and private stakeholders. Research highlights that collaborative governance frameworks support stakeholder integration, institutional coordination, shared implementation responsibility, and operational problem-solving across interconnected infrastructure systems [10]. Within NEVI implementation, collaborative governance increasingly influences utility coordination, charging interoperability, regional transportation planning, and long-term operational sustainability.

Institutional learning further contributes to sustainability-oriented infrastructure transitions by supporting iterative implementation improvement and adaptive policy development. Previous literature emphasizes that institutional learning allows organizations and governance systems to modify implementation strategies in response to operational barriers, infrastructure challenges, stakeholder feedback, and evolving policy conditions [32]. These adaptive learning processes are particularly relevant during the early implementation phases of large-scale transportation electrification programs such as NEVI.

Socio-technical transition theory also suggests that sustainable mobility transitions involve interactions among technology systems, governance structures, infrastructure networks, policy institutions, and social adaptation processes [4]. EV infrastructure deployment, therefore, extends beyond charger installation and increasingly reflects broader governance transformation, institutional coordination, and operational adaptation processes associated with long-term sustainability transitions.

Overall, adaptive governance and sustainability transition perspectives provide valuable theoretical foundations for understanding transportation electrification. However, relatively few studies have applied these perspectives to comparative longitudinal analyses examining how implementation evolves across multiple states operating under a common federal framework. This study addresses this gap by using adaptive governance

as the primary interpretive lens to evaluate the evolution of implementation across the Mid-Atlantic region.

2.7. Research Gap

The literature reviewed in this study demonstrates that substantial progress has been made in understanding EV adoption, charging accessibility, infrastructure optimization, governance, equity, and transportation electrification strategies [11,14]. Emerging studies have also examined NEVI implementation, charging equity, and individual state deployment experiences [7,16]. Nevertheless, four important research gaps remain.

First, existing studies have primarily adopted cross-sectional or state-specific perspectives, with very limited comparative longitudinal analyses examining how NEVI implementation evolved across multiple states between 2022 and 2026 under a common federal policy framework. Second, little empirical evidence explains how implementation trajectories differed across states despite operating under identical federal requirements. Third, limited attention has been paid to the unique implementation challenges of densely connected metropolitan transportation systems, including interstate corridor integration, regional mobility, and large-scale infrastructure deployment. Finally, existing research provides only a limited understanding of how governance arrangements, utility collaboration, and institutional adaptation collectively influenced implementation over time.

Accordingly, this study addresses these gaps by conducting a comparative longitudinal analysis of NEVI implementation across New York, New Jersey, and Pennsylvania and by interpreting the evolution of implementation through an adaptive governance perspective.

2.8. Conceptual Framework

This study adopts an adaptive governance and sustainability transition perspective to examine the evolution of NEVI implementation across Mid-Atlantic states from 2022 to 2026. The conceptual framework positions EV infrastructure deployment as a socio-technical transition process involving institutional coordination, collaborative governance, operational adaptation, and long-term transportation electrification planning [3,4].

The framework further emphasizes that NEVI implementation extends beyond technical charger deployment and increasingly involves metropolitan transportation electrification, interstate corridor integration, operational scalability, utility coordination, and regional infrastructure resilience. Adaptive governance and collaborative implementation processes are therefore viewed as important mechanisms that support implementation flexibility, institutional learning, and operational continuity within highly interconnected transportation systems [9,10].

In addition, the framework recognizes that dense metropolitan transportation environments, such as those in the Mid-Atlantic region, introduce additional implementation complexities related to charging demand, infrastructure scalability, regional mobility integration, and resilient operational management. Consequently, the study examines how governance adaptation, institutional coordination, and operational evolution influenced NEVI implementation across interconnected northeastern transportation corridors. The conceptual framework integrates transportation electrification, adaptive governance, and sustainability transition perspectives to provide a structured basis for interpreting how implementation evolved across states operating under a common federal policy framework.

Figure 1 illustrates the study's conceptual positioning at the intersection of transportation electrification, governance and coordination, and operational sustainability. The framework highlights that NEVI implementation involves collaborative infrastructure governance, interstate transportation integration, operational resilience, and adaptive im-

plementation processes that collectively shape the evolution of transportation electrification across the Mid-Atlantic region.

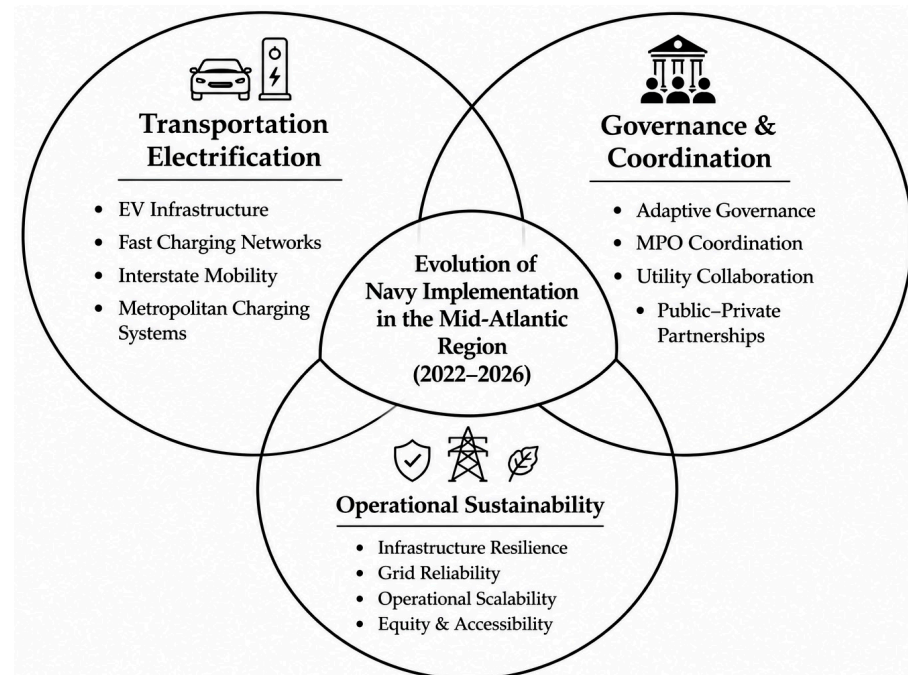


Figure 1. Conceptual framework for the evolution of NEVI implementation in the Mid-Atlantic region (2022–2026).

3. Methodology

3.1. Research Design

This study used a qualitative comparative longitudinal design to examine the evolution of NEVI implementation across Mid-Atlantic states from 2022 to 2026. This approach was appropriate because the study focused on policy evolution, institutional adaptation, governance transformation, and implementation dynamics over time rather than on a single implementation phase or isolated policy outcome [33]. Qualitative longitudinal analysis allowed the study to trace how state priorities, implementation strategies, operational concerns, and institutional responses changed across successive planning cycles [34,35].

The comparative design was also appropriate because New York, New Jersey, and Pennsylvania operated under the same federal NEVI framework while maintaining flexibility in implementation strategies, procurement approaches, utility coordination, and regional planning priorities. Comparing these states made it possible to identify both common implementation patterns and state-specific differences in infrastructure deployment, equity priorities, operational adaptation, and institutional maturation. The research design, therefore, aligned with comparative policy implementation studies that examine how shared federal policy frameworks evolve differently across regional governance systems and institutional environments [36].

3.2. Research Scope and Geographic Context

This study focused on the Mid-Atlantic region of the northeastern United States, specifically New York, New Jersey, and Pennsylvania. These states were selected because they represent one of the most complex transportation electrification environments in the country, characterized by dense metropolitan populations, highly interconnected interstate transportation corridors, extensive commuter and freight mobility networks, and substantial charging demand [3].

The three states provide an appropriate basis for comparative longitudinal analysis because they participated in the same federal implementation program during the 2022–2026 period and were subject to identical federal policy requirements while retaining flexibility in implementation strategies, governance arrangements, infrastructure planning, utility coordination, and regional transportation priorities. This combination of common federal requirements and state-level implementation diversity enables systematic comparison of how implementation evolved across different institutional and transportation contexts.

The geographical scope also offers an opportunity to examine the evolution of implementation within one of the nation’s most interconnected transportation systems, where infrastructure deployment requires coordination among metropolitan regions, interstate corridors, and multiple government agencies. Focusing on a single geographic region minimizes broad contextual variation while allowing meaningful comparison of state-level implementation approaches under a shared policy framework.

The qualitative dataset comprised official federal and state policy and implementation documents collected for comparative analysis. The composition of the document dataset and the distribution of documents by source are presented in Table 1, while the document selection process is described in Section 3.3.

Table 1. Composition of the qualitative document dataset.

Source	Document Type	Number of Documents
FHWA	NEVI Formula Program guidance, minimum standards, and implementation guidance	5
Joint Office of Energy and Transportation	Technical assistance, implementation resources, and best practices	3
New York	NEVI deployment plan and annual updates (2022–2026)	5
New Jersey	NEVI deployment plan and annual updates (2022–2026)	5
Pennsylvania	NEVI deployment plan and annual updates (2022–2026)	5
Total	—	23

3.3. Data Sources and Document Collection

This study employed qualitative document analysis using official policy and implementation documents to examine the evolution of implementation between 2022 and 2026. Document analysis is widely recognized as an appropriate qualitative research method for investigating policy development, institutional decision-making, governance evolution, and implementation processes because official documents provide direct evidence of governmental priorities, policy adaptation, and administrative actions over time [35,36].

The qualitative dataset consisted of 23 official policy and implementation documents collected from federal and state government sources. As summarized in Table 1, the dataset included federal guidance documents together with state deployment plans and annual implementation updates from New York, New Jersey, and Pennsylvania.

Documents were included when they met the following criteria: (1) published between 2022 and 2026; (2) issued by official federal or state government agencies; (3) directly related to NEVI implementation or transportation electrification policies; (4) available in full-text format; and (5) containing substantive information regarding infrastructure deployment,

governance, implementation strategies, equity, utility coordination, operational planning, or policy evolution.

Documents were excluded if they were duplicate publications, news articles, media releases, opinion pieces, presentations without substantive implementation content, incomplete records, or documents that mentioned transportation electrification only generally, without providing implementation-relevant information.

3.4. Coding Procedure and Thematic Analysis

The collected documents were analyzed using thematic analysis supported by NVivo 14 software (Lumivero, Denver, CO, USA) [37,38]. Thematic analysis provides a systematic approach for identifying, organizing, and interpreting recurring patterns within qualitative policy documents and has been widely applied in governance and public policy research [39].

The coding process followed five sequential stages. First, all documents were reviewed to achieve familiarity with their content and to identify key implementation priorities, policy changes, governance arrangements, infrastructure deployment strategies, equity considerations, utility coordination, and operational planning activities. Second, open coding was conducted to identify meaningful concepts and implementation-related issues emerging from the documents. Third, related codes were grouped through axial coding into broader analytical categories. Fourth, these categories were refined into overarching themes aligned with the study objectives. Finally, thematic comparisons were conducted across New York, New Jersey, and Pennsylvania to identify similarities, differences, and the evolution of implementation throughout the study period.

Coding was performed iteratively, with previously coded documents being revisited whenever new implementation themes emerged during later stages of the analysis [40,41]. This iterative approach improved coding consistency and ensured that themes reflected the evolution of implementation across the 2022–2026 period rather than isolated observations from individual documents.

3.5. Comparative Longitudinal Analytical Framework

The comparative longitudinal framework examined how implementation evolved across New York, New Jersey, and Pennsylvania under the same federal policy framework from 2022 to 2026 [42]. The analysis focused on changes in implementation priorities, governance arrangements, infrastructure deployment, equity considerations, operational planning, and institutional adaptation across successive planning cycles.

Cross-state comparability was maintained by applying the same analytical procedures to all three states. Each state was evaluated over the same study period using comparable document types, identical coding dimensions, and a common thematic analysis process. This approach enabled systematic comparison of implementation trajectories while accounting for differences in regional governance structures, transportation priorities, and implementation strategies.

The analytical framework emphasized five comparative dimensions: governance and institutional evolution, infrastructure deployment, equity and accessibility, operational sustainability, and policy adaptation [43,44]. These dimensions provided a consistent basis for evaluating implementation evolution across the three states and aligned with the study's research objectives.

3.6. Theoretical and Interpretive Lens

The study adopted adaptive governance and sustainability transition perspectives as the primary interpretive framework. Sustainability transition theory emphasizes that infrastructure transformation involves socio-technical adaptation processes shaped by

institutional coordination, governance evolution, operational learning, and collaborative implementation [4].

Adaptive governance perspectives further support the examination of institutional flexibility, policy learning, stakeholder coordination, and implementation responsiveness within complex infrastructure systems [9]. These perspectives are particularly relevant to transportation electrification because charging infrastructure systems involve interconnected governance, operational, utility, and mobility systems.

In addition, Kotter's Eight-Step Change Model was employed as an interpretive framework during the discussion stage to examine organizational change characteristics associated with implementation evolution, including the creation of urgency, coalition building, implementation, adaptation, and institutionalization [45–47]. The model was not used as a coding framework or an evaluation instrument during data analysis; rather, it served as a theoretical lens for interpreting the themes that emerged from the qualitative document analysis and for explaining implementation evolution across the three states.

3.7. Validation and Analytical Rigor

Several strategies were employed to strengthen analytical rigor and qualitative validity throughout the study. First, document triangulation was achieved by comparing multiple federal and state policy and implementation documents collected across the 2022–2026 study period. Second, an iterative coding process was applied in which previously coded documents were repeatedly reviewed and refined as additional documents were analyzed, thereby improving coding consistency and supporting temporal consistency throughout the longitudinal analysis.

Constant comparison was used to examine similarities and differences within and across the three states, thereby identifying recurring implementation patterns while preserving state-specific characteristics. An audit trail documenting coding decisions, theme refinement, and analytical interpretations was maintained throughout the research process to enhance transparency and analytical consistency.

Thematic stability was achieved when successive document reviews no longer produced substantially new implementation themes, indicating that the analytical framework adequately captured the major patterns present in the dataset. Finally, theoretical triangulation was achieved by interpreting the findings through adaptive governance, sustainability transition theory, and Kotter's Eight-Step Change Model, thereby strengthening conceptual validity and supporting the interpretation of implementation evolution across multiple institutional contexts [48].

3.8. Study Limitation

This study has several limitations. First, the analysis relied exclusively on publicly available policy and implementation documents rather than interviews, surveys, or quantitative infrastructure performance data. Consequently, the findings reflect documented implementation priorities and institutional responses rather than the perspectives of individual stakeholders or direct measures of implementation performance. Second, the study focused specifically on New York, New Jersey, and Pennsylvania and, therefore, may not fully represent implementation conditions or governance dynamics in other U.S. regions. Third, variations in the availability, level of detail, and frequency of publicly available documents across states may have influenced the richness of evidence available for comparative analysis. Although common document selection criteria and analytical procedures were applied to all states, differences in publicly reported information may have affected the depth of evidence supporting individual implementation themes. Finally, because implementation remains an ongoing process, future policy developments, infrastructure

investments, technological advances, and institutional adaptations beyond the 2022–2026 study period may influence implementation trajectories not captured in this analysis.

4. Results

The comparative longitudinal analysis identified significant patterns in the evolution of implementation across the three Mid-Atlantic states between 2022 and 2026. Although New York, New Jersey, and Pennsylvania operated under the same federal implementation framework, distinct differences emerged in governance coordination, infrastructure deployment, equity priorities, operational adaptation, utility collaboration, and institutional learning. Comparative analysis of the official deployment plans and annual implementation updates demonstrated that implementation evolved beyond initial corridor compliance toward broader transportation electrification strategies emphasizing infrastructure scalability, system reliability, equitable accessibility, and long-term sustainability.

As summarized in Table 2, the three states followed different implementation trajectories despite operating under identical federal requirements. New York demonstrated the most comprehensive implementation approach through large-scale statewide infrastructure planning, expanded utility coordination, metropolitan charging integration, and continuous policy refinement. New Jersey emphasized adaptive implementation by strengthening metropolitan accessibility, corridor redundancy, operational reliability, and alignment with statewide zero-emission transportation objectives. Pennsylvania adopted a more gradual implementation trajectory characterized by phased infrastructure deployment, expansion of charging accessibility across rural and interstate corridors, procurement-related implementation challenges, and increasing institutional coordination to support long-term transportation electrification.

Table 2. Comparative evolution of implementation dimensions across the Mid-Atlantic states (2022–2026).

Implementation Dimension	New York	New Jersey	Pennsylvania
Governance Evolution	Governance evolved toward integrated multi-agency coordination involving NYSERDA, NYDOT, utilities, and regional transportation stakeholders, supporting statewide implementation and long-term transportation electrification planning.	Governance expanded through coordination among NJDOT, NJDEP, utilities, and regional clean transportation initiatives, with increasing emphasis on adaptive implementation and alignment with statewide ZEV objectives.	Governance evolved through gradual interagency collaboration, incentive-supported implementation, and regional planning that balanced statewide priorities with local deployment needs.
Infrastructure Deployment Evolution	Infrastructure deployment progressed from corridor compliance toward statewide fast-charging expansion, metropolitan accessibility, interstate connectivity, and strategic investment in charging infrastructure.	Deployment evolved from Turnpike-focused implementation toward broader metropolitan accessibility, network redundancy, and statewide charging expansion.	Deployment followed a phased implementation strategy emphasizing interstate highway connectivity, regional accessibility, rural charging expansion, and gradual statewide infrastructure development despite procurement and implementation challenges.

Table 2. *Cont.*

Implementation Dimension	New York	New Jersey	Pennsylvania
Equity and Accessibility Evolution	Equity priorities expanded to include disadvantaged communities, multifamily housing, underserved urban neighborhoods, and improved statewide charging accessibility.	Equity implementation increasingly emphasized Justice40 priorities, affordable metropolitan charging access, and improved accessibility for underserved communities.	Equity priorities focused on expanding charging accessibility across rural communities, underserved regions, and geographically dispersed transportation corridors through incentive-supported infrastructure deployment.
Utility and Operational Evolution	Operational planning increasingly emphasized utility partnerships, interoperability, charger reliability, cybersecurity preparedness, preventive maintenance, and long-term system resilience.	Utility coordination expanded through preventive maintenance planning, operational reliability, infrastructure resilience, and scalable charging network management.	Operational planning emphasized grid coordination, infrastructure continuity, maintenance planning, and adaptive operational management to support long-term deployment across geographically dispersed service areas.
Institutional and Policy Evolution	Institutional adaptation reflected continuous policy refinement, transportation electrification planning, market responsiveness, and long-term clean energy integration.	Policy evolution increasingly emphasized sustainable mobility, adaptive planning, and coordination between transportation and clean energy initiatives.	Institutional evolution reflected incremental policy learning, infrastructure incentive programs, regional coordination, and continuous adaptation of transportation electrification strategies.

The comparative findings further indicate that implementation priorities evolved throughout the study period. Earlier deployment plans primarily emphasized corridor compliance and minimum charging requirements, whereas later annual updates increasingly incorporated operational resilience, interoperability, utility partnerships, cybersecurity preparedness, equity considerations, and long-term infrastructure sustainability. These findings demonstrate that implementation progressed from federally guided infrastructure deployment toward more integrated transportation planning supported by adaptive governance and continuous institutional learning.

4.1. Evolution of Governance and Institutional Coordination

The comparative analysis identified substantial evolution in governance structures and institutional coordination across the three Mid-Atlantic states between 2022 and 2026. As summarized in Table 2, early implementation efforts primarily focused on meeting federal program requirements and corridor deployment objectives. Successive annual deployment updates, however, demonstrated a gradual transition toward broader institutional coordination involving transportation agencies, environmental agencies, utilities, metropolitan planning organizations (MPOs), and private-sector stakeholders responsible for infrastructure planning and implementation.

New York demonstrated the most comprehensive governance evolution through expanding collaboration among NYSERDA, NYDOT, utility providers, regional transporta-

tion organizations, and other implementation partners. The annual deployment updates increasingly emphasized integrated planning, interagency coordination, and statewide transportation electrification strategies that supported infrastructure scalability, operational continuity, and long-term implementation planning.

New Jersey likewise strengthened governance coordination by expanding collaboration among NJDOT, NJDEP, utility providers, and clean transportation partners. Later implementation documents reflected increasing emphasis on adaptive planning, cross-agency coordination, and alignment with statewide ZEV objectives, demonstrating a progressive shift from corridor compliance toward broader sustainable transportation planning.

Pennsylvania exhibited a more gradual evolution in governance, characterized by phased institutional coordination, implementation through infrastructure incentive programs, and increasing collaboration among transportation agencies and regional stakeholders. The state's implementation documents also highlighted the need to balance metropolitan deployment priorities with rural accessibility, long-distance transportation corridors, procurement processes, and regional implementation challenges, resulting in a more incremental implementation trajectory than those observed in New York and New Jersey.

Overall, the comparative findings indicate that governance evolution across the Mid-Atlantic region progressed beyond initial federal compliance toward increasingly collaborative, adaptive, and institutionally integrated implementation approaches. Although all three states operated under the same federal framework, differences in governance structures, implementation capacity, and regional transportation priorities produced distinct implementation trajectories while supporting the broader transition toward sustainable transportation electrification.

4.2. Evolution of Infrastructure Deployment Strategies

The comparative analysis revealed substantial evolution in infrastructure deployment strategies across the Mid-Atlantic states between 2022 and 2026. As summarized in Table 2, the initial implementation phase primarily emphasized compliance with federally designated corridor requirements and minimum fast-charging coverage. Successive annual deployment updates, however, demonstrated a gradual transition toward broader statewide charging accessibility, metropolitan network expansion, interstate connectivity, infrastructure scalability, and long-term transportation electrification planning.

New York demonstrated the most comprehensive infrastructure deployment strategy by progressively expanding fast-charging infrastructure beyond Alternative Fuel Corridors to support metropolitan accessibility, statewide network integration, and regional mobility. Later implementation updates increasingly emphasized strategic charger placement, infrastructure scalability, operational reliability, and integration with major interstate transportation corridors to accommodate growing charging demand.

New Jersey similarly evolved from an initial corridor-focused implementation strategy toward broader metropolitan charging accessibility, network redundancy, and statewide infrastructure expansion. The implementation documents reflected increasing attention to charging availability within densely populated urban areas while strengthening regional connectivity, infrastructure resilience, and operational continuity through coordinated deployment planning.

Pennsylvania adopted a more gradual implementation trajectory characterized by phased infrastructure expansion across interstate highways, regional transportation corridors, and rural communities. The implementation documents highlighted several deployment challenges, including procurement processes, geographically dispersed service areas, long-distance travel corridors, and utility coordination requirements. These factors influ-

enced the pace of infrastructure expansion while reinforcing the importance of balancing statewide accessibility with regional implementation priorities.

Overall, the comparative findings indicate that infrastructure deployment evolved beyond initial corridor compliance toward integrated charging networks designed to improve statewide accessibility, strengthen regional connectivity, support operational resilience, and facilitate long-term transportation electrification. Although all three states followed the same federal implementation framework, differences in transportation demand, metropolitan complexity, and regional implementation conditions resulted in distinct deployment strategies and implementation trajectories.

4.3. Evolution of Equity and Accessibility Priorities

The comparative analysis demonstrated substantial evolution in equity and accessibility priorities across the Mid-Atlantic states between 2022 and 2026. As summarized in Table 2, the initial implementation phase primarily focused on Justice40 objectives and improving charging accessibility along designated transportation corridors. Successive annual deployment updates, however, reflected a broader interpretation of equity that increasingly emphasized underserved urban and rural communities, disadvantaged populations, multifamily housing, regional accessibility, and equitable distribution of charging infrastructure throughout statewide transportation networks.

New York demonstrated the most comprehensive expansion of equity priorities by progressively incorporating disadvantaged urban communities, multifamily housing, and broader statewide charging accessibility into infrastructure planning. Later implementation documents increasingly emphasized improving charging confidence, reducing geographic disparities, and integrating equity considerations into long-term transportation electrification planning.

New Jersey similarly expanded its equity strategy beyond initial federal compliance by strengthening affordable metropolitan charging accessibility and improving charging availability for underserved communities within densely populated transportation environments. The implementation updates reflected increasing attention to equitable infrastructure distribution, public accessibility, and coordinated planning that aligned charging deployment with broader sustainable mobility objectives.

Pennsylvania adopted a more gradual evolution of equity priorities by emphasizing improved charging accessibility across rural communities, underserved regions, and geographically dispersed transportation corridors. The implementation documents highlighted the importance of expanding charging opportunities beyond metropolitan areas through incentive-supported deployment strategies while addressing regional accessibility challenges associated with lower population density and longer travel distances.

Overall, the comparative findings indicate that equity and accessibility priorities evolved from compliance-oriented implementation toward broader sustainability-oriented transportation planning. Although each state adopted different implementation strategies, all three increasingly integrated equitable charging accessibility into long-term infrastructure planning, reflecting the growing importance of inclusive transportation electrification across both metropolitan and regional transportation systems.

4.4. Utility Coordination and Operational Adaptation

The comparative analysis demonstrated that utility coordination and operational adaptation became increasingly important implementation priorities across the Mid-Atlantic states between 2022 and 2026. As summarized in Table 2, early implementation efforts primarily emphasized infrastructure deployment and charger installation. Successive annual deployment updates, however, reflected increasing attention to utility coordination, grid

resilience, interoperability, preventive maintenance, operational continuity, cybersecurity preparedness, and long-term infrastructure scalability as charging networks expanded.

New York demonstrated the most comprehensive operational evolution by progressively strengthening utility partnerships, interoperability standards, charger reliability, and long-term operational continuity. Later implementation documents increasingly emphasized network resilience, cybersecurity preparedness, and coordinated operational planning to support the expansion of statewide charging infrastructure and reliable system performance.

New Jersey similarly expanded its operational priorities by strengthening coordination with utility providers, planning preventive maintenance, enhancing infrastructure resilience, and managing a scalable charging network. Successive implementation updates reflected increasing attention to maintaining reliable charging services, supporting operational continuity, and integrating utility planning into long-term transportation electrification strategies.

Pennsylvania adopted a more gradual operational evolution that emphasized grid coordination, infrastructure continuity, maintenance planning, and adaptive operational management to support charging deployment across geographically dispersed service areas. The implementation documents also highlighted the importance of coordinating infrastructure expansion with utility capacity, addressing operational challenges associated with rural and interstate transportation corridors, and supporting long-term network reliability.

Overall, the comparative findings indicate that operational priorities evolved beyond charger deployment toward comprehensive charging network management. Although implementation approaches differed across the three states, all increasingly recognized that reliable charging infrastructure depends on coordinated utility planning, operational resilience, interoperability, cybersecurity preparedness, and continuous infrastructure management to support long-term transportation electrification.

4.5. Institutional Maturation and Policy Evolution

The comparative analysis identified substantial institutional maturation and policy evolution across the Mid-Atlantic states between 2022 and 2026. As summarized in Table 2, the initial implementation phase primarily reflected federally guided infrastructure deployment objectives and compliance-oriented planning requirements. Successive annual deployment updates, however, demonstrated increasing institutional learning, policy refinement, interagency coordination, and long-term strategic planning that extended beyond initial implementation requirements.

New York demonstrated the most comprehensive institutional evolution by progressively refining statewide transportation electrification strategies, integrating market-responsive planning approaches, and strengthening coordination among transportation, energy, and infrastructure stakeholders. Later implementation documents reflected continuous policy adaptation, expanding implementation priorities, and long-term planning that supported sustained infrastructure deployment and operational improvement.

New Jersey likewise demonstrated significant institutional maturation through the integration of sustainable mobility objectives, adaptive infrastructure planning, and long-term coordination supporting the statewide ZEV transition. Successive implementation updates reflected increasing policy alignment across transportation, environmental, and energy agencies while strengthening institutional capacity to respond to evolving implementation priorities.

Pennsylvania exhibited a more gradual pattern of institutional evolution characterized by incremental policy learning, refinement of infrastructure incentive programs, strengthened operational coordination, and continued adaptation of statewide implementation

strategies. The implementation documents reflected increasing institutional attention to balancing metropolitan deployment priorities with regional accessibility, rural transportation needs, and long-term infrastructure planning.

Overall, the comparative findings indicate that institutional development evolved beyond compliance-oriented infrastructure deployment toward increasingly coordinated, adaptive, and strategically integrated implementation. Although the three states followed different implementation pathways, each demonstrated progressive institutional learning and policy refinement that supported the broader transition toward sustainable transportation electrification and long-term infrastructure management.

5. Discussion

5.1. NEVI Implementation as a Sustainability Transition Process

The findings suggest that NEVI implementation across the Mid-Atlantic region evolved from a federally guided infrastructure deployment initiative to a broader, sustainability-oriented transportation transition. Initial efforts focused on Alternative Fuel Corridor compliance, charger deployment, and minimum infrastructure coverage requirements. Over time, however, implementation increasingly emphasized operational resilience, urban accessibility, interoperability, and long-term planning for transportation electrification. These findings align with sustainability transition literature, which suggests that transportation electrification requires not only infrastructure expansion but also institutional adaptation, adaptive governance, collaborative governance, and socio-technical coordination [3,4].

The Mid-Atlantic states exhibited varying implementation trajectories shaped by metropolitan transportation complexity, regional mobility integration, infrastructure scalability, and institutional coordination. New York's more advanced implementation trajectory appears to reflect its greater institutional capacity, established clean-energy governance structure, stronger utility partnerships, and mature transportation planning systems. These conditions enabled the state to move beyond federal compliance toward broader transportation electrification objectives. New Jersey increasingly emphasized metropolitan charging accessibility and adaptive transportation coordination, while Pennsylvania showed a more gradual implementation evolution, reflecting the challenges associated with its larger geographic area, extensive rural transportation corridors, dispersed charging demand, and the greater coordination required to expand charging infrastructure across diverse regional contexts. These differences further suggest that implementation trajectories were influenced by variations in utility readiness, metropolitan complexity, institutional capacity, and regional transportation characteristics, thereby affecting the pace and scope of implementation within the same federal framework. These findings support previous research emphasizing that implementation outcomes are strongly influenced by governance coordination, institutional flexibility, and operational readiness rather than solely by federal funding [7].

5.2. Adaptive Governance and Institutional Coordination

The comparative findings indicate that adaptive governance played a key role in shaping the evolution of implementation across the Mid-Atlantic region. Although all three states operated under the same federal NEVI framework, implementation adaptation varied because differences in institutional coordination, utility collaboration, existing infrastructure maturity, transportation complexity, and operational planning capacity influenced each state's ability to respond to evolving implementation priorities under a common federal framework. These findings align with adaptive governance literature, which emphasizes that large-scale infrastructure transitions require collaborative coordination, institutional learning, and implementation flexibility within evolving socio-technical

systems [9]. The findings, therefore, suggest that adaptive governance functioned as an enabling mechanism through which public agencies, utility providers, and regional stakeholders coordinated evolving implementation priorities while responding to changing operational, technological, and infrastructure requirements.

The findings further demonstrate increasing coordination among transportation agencies, utility providers, MPOs, environmental agencies, and private charging stakeholders. This collaborative implementation pattern supports previous governance studies, suggesting that transportation electrification increasingly depends on interconnected regional governance systems rather than isolated infrastructure deployment initiatives [11]. These findings suggest that institutional coordination became a critical enabling factor for maintaining operational continuity, expanding charging accessibility, supporting infrastructure scalability, and facilitating long-term transportation electrification within highly interconnected metropolitan transportation systems.

5.3. Interpretation Through Kotter's Eight-Step Change Model

Kotter's Eight-Step Change Model served as an interpretive framework for examining the evolution of implementation, institutional adaptation, and collaborative coordination across the three Mid-Atlantic states. Rather than functioning as a measurement instrument or being statistically tested, the framework was applied to interpret patterns of organizational transition reflected in the comparative document analysis. The interpretation focused on organizational change characteristics associated with urgency creation, coalition building, adaptive implementation, barrier removal, and institutionalization throughout the implementation period [46].

The interpretation presented in Table 3 was derived from the comparative analysis of official implementation documents rather than quantitative scoring. Each Kotter dimension was evaluated by examining the consistency, breadth, and evolution of implementation evidence across the study period. States demonstrating sustained evidence of coordinated implementation, institutional learning, policy refinement, operational adaptation, and stakeholder collaboration were interpreted as exhibiting more advanced characteristics of organizational transition, whereas states showing moderate or emerging evidence of these characteristics were classified accordingly. Consequently, the framework was used to explain differences in implementation maturity rather than to assign numerical performance scores.

Table 3. Qualitative interpretation criteria for applying Kotter's Eight-Step Change Model.

Interpretation Level	Qualitative Interpretation
Advanced	Consistent and well-developed evidence of implementation evolution, institutional learning, stakeholder coordination, and organizational adaptation across the implementation period.
Strong	Clear evidence of coordinated implementation and organizational transition, with continued development in selected implementation dimensions.
Moderate	Evidence of implementation progress and institutional adaptation, although development remained uneven across implementation dimensions.
Emerging	Initial evidence of organizational transition and institutional learning, with substantial opportunities for continued implementation and development.

The comparative interpretation suggests that implementation reflected gradual organizational and institutional transitions shaped by adaptive governance, collaborative implementation, and continuous organizational learning. Differences in implementation maturity appear to have resulted from variations in institutional capacity, utility collaboration, existing infrastructure maturity, metropolitan transportation complexity, and organizational readiness to respond to evolving implementation priorities. These findings indicate that successful implementation depended not only on infrastructure deployment but also on the institutional capacity to sustain stakeholder collaboration, policy learning, and continuous organizational adaptation.

As summarized in Table 3, New York demonstrated the highest implementation maturity, reflecting sustained coalition-building, continuous institutional learning, and progressive integration of transportation, energy, and infrastructure planning throughout the implementation period. New Jersey demonstrated strong organizational transition through effective coalition development, adaptive implementation, and coordinated metropolitan transportation planning while continuing to strengthen institutionalization processes. Pennsylvania exhibited a more gradual organizational transition characterized by phased implementation, progressive institutional learning, and continued adaptation of governance and operational coordination to address regional deployment challenges.

The qualitative interpretation of implementation maturity across the three states is summarized in Table 4.

Table 4. Cross-state interpretation of Mid-Atlantic implementation through Kotter’s Eight-Step Change Model.

Kotter Dimension	New York	New Jersey	Pennsylvania
Urgency Creation	Advanced	Strong	Moderate
Coalition Building	Advanced	Strong	Moderate
Adaptive Implementation	Advanced	Strong	Emerging
Barrier Removal	Strong	Moderate	Moderate
Institutionalization	Advanced	Moderate	Emerging

Overall, the interpretation supports the organizational change literature, suggesting that large-scale sustainability initiatives evolve through progressive institutional learning, collaborative governance, adaptive implementation, and continuous organizational refinement rather than through linear infrastructure deployment alone [3,47]. The findings further indicate that Kotter’s framework provides a useful interpretive perspective for understanding how implementation maturity developed differently across states operating under a common federal policy framework while responding to distinct institutional, operational, and geographic conditions.

5.4. Operational Sustainability and Metropolitan Infrastructure Complexity

The findings highlight that operational sustainability became an increasingly important component of transportation electrification as implementation progressed across the Mid-Atlantic region. While the initial implementation phase primarily emphasized charging deployment and infrastructure accessibility, later implementation increasingly focused on interoperability, preventive maintenance, cybersecurity preparedness, utility coordination, operational continuity, and long-term infrastructure resilience. This progression suggests that implementation priorities evolved in response to the growing operational complexity associated with expanding charging networks rather than infrastructure deployment alone.

The differing implementation trajectories further indicate that operational sustainability was influenced by variations in metropolitan transportation complexity, utility readiness,

existing infrastructure maturity, and regional mobility patterns. Dense metropolitan environments require greater coordination among transportation agencies, utility providers, and infrastructure operators to maintain charging reliability, support increasing electricity demand, and ensure continuity of service. In contrast, implementation in geographically dispersed areas required balancing operational efficiency with broader regional accessibility and long-distance transportation connectivity.

These findings are consistent with previous infrastructure resilience studies, which suggest that large-scale charging networks increasingly function as interconnected socio-technical systems requiring continuous maintenance, coordinated utility planning, operational learning, and adaptive management rather than isolated infrastructure investments [18,24]. Consequently, operational sustainability should be viewed not only as a technical requirement but also as an institutional capability that enables long-term transportation electrification through sustained collaboration among public agencies, utility providers, and other implementation stakeholders.

Overall, the findings suggest that implementation evolved beyond infrastructure deployment toward integrated operational management supported by adaptive governance, collaborative institutional coordination, and continuous organizational learning. This evolution demonstrates that long-term transportation electrification depends on maintaining resilient operational systems that can adapt to changing technological, institutional, and transportation demands in highly interconnected metropolitan environments.

6. Conclusions

This study examined the evolution of NEVI implementation across the Mid-Atlantic states from 2022 to 2026 using a comparative longitudinal design. The findings showed that implementation moved beyond federally guided charging corridor deployment toward broader, sustainability-oriented transportation electrification, characterized by adaptive governance, institutional coordination, operational resilience, and long-term infrastructure planning. Although New York, New Jersey, and Pennsylvania operated under the same federal policy framework, implementation trajectories differed due to variations in institutional capacity, metropolitan transportation complexity, infrastructure maturity, utility readiness, and governance coordination.

The study further demonstrated that transportation electrification increasingly functions as a socio-technical transition that requires collaborative governance, utility coordination, operational sustainability, and continuous institutional adaptation. New York exhibited the most advanced implementation trajectory, characterized by integrated transportation electrification planning, resilient infrastructure coordination, and sustained organizational learning. New Jersey emphasized metropolitan accessibility, coordinated implementation, and scalable charging network expansion, whereas Pennsylvania demonstrated a more gradual implementation trajectory shaped by regional deployment complexity, rural accessibility considerations, and phased institutional adaptation.

The findings support the adaptive governance and sustainability transition literature by showing that large-scale infrastructure transitions evolve through collaborative implementation, institutional learning, operational adaptation, and interconnected governance systems rather than infrastructure deployment alone. Furthermore, the interpretive application of Kotter's Eight-Step Change Model shows that implementation maturity varied across the three states, reflecting differences in urgency creation, coalition building, adaptive implementation, barrier removal, and institutionalization, providing additional insight into the organizational processes that support long-term transportation electrification.

This study also makes several contributions to the emerging NEVI literature. First, it advances comparative implementation research by offering one of the earliest comparative

longitudinal analyses of how implementation evolved across Mid-Atlantic states operating under a common federal policy framework from 2022 to 2026. Second, it extends the adaptive governance literature by demonstrating how institutional capacity, collaborative implementation, and organizational learning shaped implementation trajectories beyond federal compliance requirements. Third, it contributes to sustainability transition research by showing that transportation electrification constitutes a socio-technical transition that requires coordinated governance, operational adaptation, and long-term institutional development rather than infrastructure deployment alone.

The findings offer several practical recommendations for future implementation. Transportation agencies should strengthen interagency coordination and integrate long-term operational planning into charging infrastructure deployment strategies. Policymakers should continue to support adaptive implementation frameworks that promote institutional learning, collaborative governance, and regional coordination while maintaining sufficient flexibility to respond to evolving implementation needs. Utility providers should expand coordination with transportation agencies to improve grid readiness, interoperability, operational resilience, and long-term charging network reliability. Metropolitan planning organizations and regional transportation partners should further integrate charging infrastructure planning into broader transportation, land-use, and regional mobility strategies to support equitable and sustainable transportation electrification.

Several future research directions emerge from this study. Future comparative longitudinal research should examine the evolution of implementation across additional U.S. regions, ultimately supporting a national comparative synthesis of NEVI implementation under a common federal policy framework. Mixed-methods research combining qualitative document analysis with stakeholder interviews and quantitative infrastructure performance indicators would provide a more comprehensive understanding of implementation effectiveness. Future studies may also evaluate charger reliability, infrastructure utilization, utility integration, workforce readiness, operational resilience, and long-term implementation outcomes to further advance transportation electrification research.

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Abbreviations

The following abbreviations are used in this manuscript:

AFC	Alternative Fuel Corridor
BIL	Bipartisan Infrastructure Law
EV/EVs	Electric Vehicle/Electric Vehicles
FHWA	Federal Highway Administration
MPO	Metropolitan Planning Organization
NEVI	National Electric Vehicle Infrastructure
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NYDOT	New York State Department of Transportation
NYSERDA	New York State Energy Research and Development Authority
ZEV	Zero-Emission Vehicle

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