EXAMINING THE ENERGY SECURITY-EQUITY NEXUS IN NOVA SCOTIA'S TRANSITION TO ELECTRIC VEHICLES

By

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ABSTRACT

This research examines the complex relationship between energy security, equity, and widespread adoption of electric vehicles (EVs), emphasizing the development of tailored indicators to assess jurisdictional progress. Drawing inspiration from California's leadership, we develop indicators that include equitable charging infrastructure distribution, affordability for diverse communities, integration of renewable energy sources, accessibility of education programs, and the impact of government fleet electrification on underserved communities. By applying these indicators to Nova Scotia, the paper aims to provide a comprehensive assessment of the province's efforts, providing insights into successes and areas for improvement. The research contributes an innovative methodology for evaluating EV policy implementation, aligned with the dual goals of enhancing energy security and promoting equity in the transition to electric mobility.

LIST OF ABBREVIATIONS USED

AC Alternating Current
BEV Battery Electric Vehicle
CAB California Assembly Bill
CALeVIP California Electric Vehicle Infrastructure Project
CARB California Air Resource Board
CCE California Climate Agreement
CCI Canadian Climate Institute
CCRA Climate Change Reduction Act
CEC California Energy Commission
CF Clean Foundation
CPP Critical Peak Price
CPUC California Public Utilities Commission
CVRP California Vehicle Rebate Project
CVRP Clean Vehicle Rebate Project
CWDB California Workforce Development Board
DC Direct Current
EAC Ecology Action Centre
EPICP Electric Program Investment Cost Project
EVITP Electric Vehicle Infrastructure Training Program
FCEV Fuel Cell Electric Vehicle
GHG Green House Gas
HRM Halifax Regional Municipality
IAM Integrated Assessment Models
ICEV Internal Combustion Engine Vehicle
IEPR Independent External Peer Review
IPCC Intergovernmental Panel on Climate Change
LCFS Low Carbon Fuel Standard
LEV Low Emission Vehicle
MSRP Manufacturer's Suggested Retail Price
MT Mega Tons
MURB Multiple Unit Residential Building
NBER National Bureau of Economic Research
NEF National Energy Foundation
NIR National Inventory Report
NRC National Resources Canada
NSCC Nova Scotia Community College
NSP Nova Scotia Power
OBPS Output Based Pricing System
PEV Plug-in Electric Vehicle
PHEV Plug-in Electric Vehicle
RPP Refined Petroleum Products
RPS Renewable Portfolio Standards
SCE Southern California Edison
ZEV Zero Emission Vehicle

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1. INTRODUCTION

In October 2018, the Intergovernmental Panel on Climate Change (IPCC) emphasized the urgent need to limit global warming to 1.5°C above pre-industrial levels to avoid the severe effects of climate change. The US, EU, and UK are leading to cut emissions targets among the world's biggest economies (Wood, 2023). The UK has committed to cut emissions faster than other developed nations, with a target of 68% cuts by 2030 (Government of UK, 2024). Canada has committed to reduce emissions to a target of 40 to 45% below 2005 levels by 2030 to put them on a path to achieve net-zero emissions by 2050 according to the Emission Reduction Plan 2030 (Government of Canada, 2022). The Canadian Climate Institute's commentary on the Government of Canada's 2021 NIR further underscores Canada's progress. According to the 2021 inventory data, Canada's emissions were 8.4% below 2005 levels, marking a significant step towards the 2030 goal (CCI, 2022). However, these reductions were influenced significantly by the COVID-19 pandemic. The pandemic led to substantial declines in economic activity, transportation, and energy consumption, contributing to the temporary reduction in greenhouse gas (GHG) emissions. However, as restrictions eased and economic activities resumed, emissions began to rise again. Despite a slight increase in emissions in 2021 compared to 2020, this rise was smaller than the country's economic growth, showing an effective decoupling of emissions from economic activity (IEA, 2022). Nova Scotia has committed to reducing its GHG emissions by 53% from 2005 levels by 2030 to stay below 1.5^0C of warming according to the provincial government (NSGovt, 2022). This global imperative calls for transformative changes in all sectors of the economy, particularly those with high emission intensity, such as transport.

The transportation sector in Canada is a significant contributor to the country's greenhouse gas (GHG) emissions. According to the 2023 National Inventory Report (NIR), transportation accounted for 150 megatons (MT) of GHG emissions in 2021, representing nearly a quarter (approximately 21%) of Canada's total emissions (Government of Canada, 2024). This sector includes emissions from various modes of transport such as on-road vehicles, rail, airplanes, and boats, with most of the energy used coming from refined petroleum products (RPPs) derived from crude oil (Government of Canada, 2024). Figure 1 shows the total metric tons of greenhouse gas emissions in Canada across five modes (aviation, rail, marine, on-road passenger, and on-road freight) in 2022. This shows that most of these emissions are due to on-road transport (Transport Canada, 2022). It suggests that personal vehicles are a major source of GHG emissions, pointing to the need for policies and technologies that reduce emissions from cars, such as promoting electric vehicles (EVs), improving fuel efficiency, and enhancing public transit.

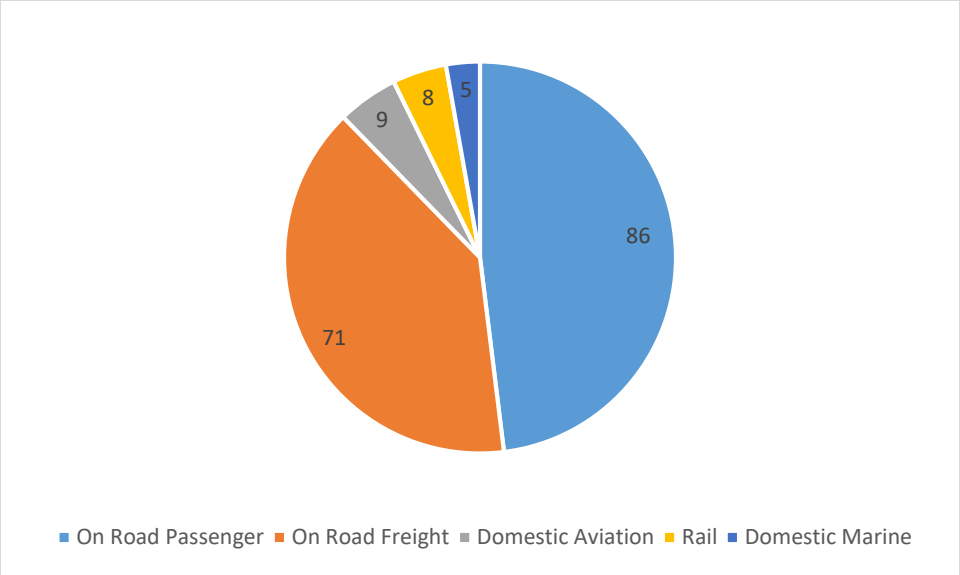

Figure 1 GHG emissions in Canada across five modes of transportation in 2022 (Government of Canada, 2022)

In 2022, Canada's greenhouse gas (GHG) emissions across all sectors totaled 708 million metric tons of CO_2 equivalent. The breakdown by sector is shown in Figure 2. For comparison, the energy sector alone is a significant contributor compared to other sectors, with transportation within this sector being a major source of emissions. In terms of individual gases, carbon dioxide (CO_2) made up 78% of the emissions, followed by methane (CH_4) at 17%, and nitrous oxide (N_2O) at 4%. The remaining emissions were from synthetic gases (HFCs, PFCs, SF_6, and NF_3) (Government of Canada, 2022).

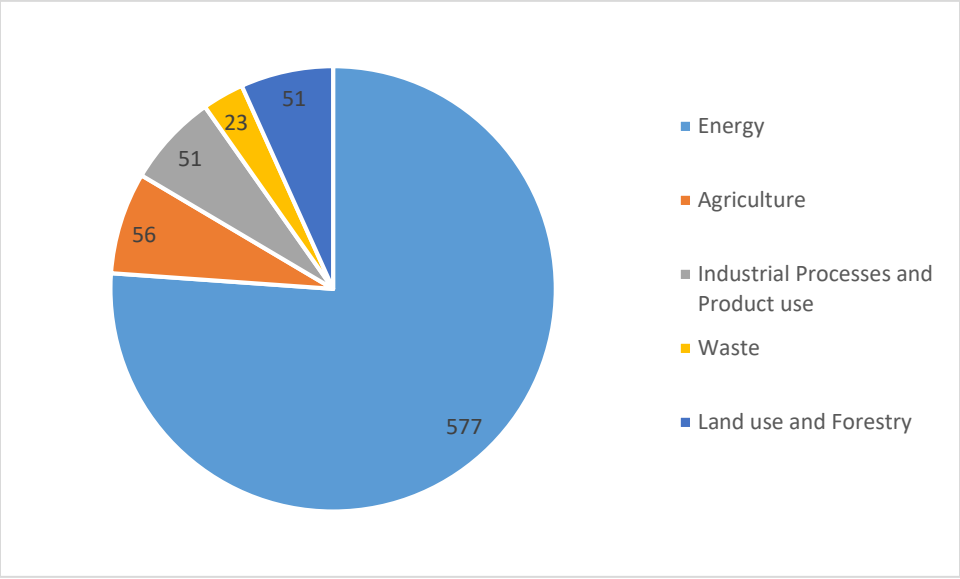

Figure 2 Canada's GHG emissions across all sectors in 2022 (Government of Canada, 2022)

In 2021, the Government of Canada took steps to encourage the adoption of ZEVs across the country and established a mandatory target of 100% light-duty vehicle ZEV sales by 2035 (Government of Canada, 2022). Between the program's launch on May 2019 and December 2021, Transport Canada's Zero

Emission Vehicle program benefited 127,000 Canadians and Canadian businesses. This program provides financial incentives to encourage the adoption of zero-emission vehicles. The incentives help reduce the cost of purchasing or leasing new zero-emission vehicles. The iZEV program offers rebates of up to $5,000 for the purchase or lease of eligible battery-electric, hydrogen fuel cell, and longer-range plug-in hybrid vehicles (Transport Canada, 2024). The iZEV program's popularity grew significantly in the 2021 calendar year, which saw a drop in demand due to the COVID-19 pandemic. This program and other federal zero-emission vehicle investments helped increase the zero-emission vehicle market share of light-duty vehicles to 13.3% in the third quarter of 2023 which is a notable increase from previous years. This represents a significant rise from 5.6% in 2021 (Environment and Climate Change Canada, 2022).

One of the most crucial tactics to lower emissions is the move towards Zero Emission Vehicles (ZEVs), which includes both Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs). However, the transition is fraught with challenges, including the upfront costs associated with ZEVs, performance concerns such as range concerns, and the need for extensive charging infrastructure. Leading North American regions where EV adoption rates are reaching up to 10% of new vehicle sales include areas such as California in the United States, British Columbia, and Quebec in Canada due to a combination of strong government incentives, robust charging infrastructure, and greater public awareness and support for clean energy initiatives (IEA, 2024). However, the existing federal incentives of up to $5,000 for new battery-electric vehicles (BEVs), hydrogen fuel cell vehicles (FCVs), and longer-range plug-in hybrid vehicles (PHEVs) and up to $2,500 for shorter-range PHEVs alone are projected to only help Nova Scotia reach about half of the 2030 federal ZEV target (Transport Canada, 2024). To help achieve the 2030 federal ZEV target of 30% of new light-duty vehicle sales to be ZEVs by 2030, 100% by 2035, it is necessary to introduce provincial incentives along with federal incentives. The provincial government of Nova Scotia also has a target of 30% of new vehicle sales to be ZEVs by 2030. Despite these efforts, the adoption rate of EVs in Nova Scotia and across Canada remains low, necessitating a more in-depth analysis of the barriers to ZEV uptake and the development of strategies to overcome them.

1.1 Disparities among Low-Income Communities

The adoption of EVs is particularly uneven among different socioeconomic groups, with low-income and disadvantaged communities facing significant barriers that hinder their access to the benefits of EVs (Brower, 2023) These barriers include financial challenges such as the high cost of new EVs, uncertainty around resale value, and limited access to affordable financing options (Lee & Clark, 2018). Reliable and widespread access to charging infrastructure is crucial for EV adoption. This includes the availability of home charging options as well as public charging stations. A volatile market, fueled by rapid technological advances and intense competition, further complicates the viability of EV adoption for those with limited budgets. In addition, the design of incentive programs often does not adequately cater to low-income individuals, with many incentives either inaccessible to them or structured to disproportionately benefit higher-income households. This results in a situation where most current EV buyers are high-income, well-educated, and predominantly white individuals, exacerbating environmental and transportation disparities (Forsythea, Gillinghamb, Michaleka, & Kate S. Whitefoota, 2023).

Furthermore, low-income communities face infrastructure challenges, including a lack of charging options in multi-family residences and "charging deserts" in disadvantaged neighborhoods (Forsythea, Gillinghamb, Michaleka, & Kate S. Whitefoota, 2023). Public charging infrastructure is more concentrated in affluent areas, leading to uneven distribution that exacerbates socio-economic divides (Hardman, Fleming, Khare, & Ramadan, 2021).

1.2 Concerns over Energy Security-Equity

The reliable availability of energy at affordable prices is referred to as energy security. It also involves ensuring a stable supply of energy (availability), ensuring that the energy sources and technologies used must be acceptable to the public (acceptability), and keeping energy prices stable and manageable for all consumers (affordability) (Hughes & de Jong, 2021). Energy justice refers to the goal of achieving fairness and equity in both the social and economic participation in the energy system. It also aims to address and remedy the social, economic and health burden on communities that have been disproportionately harmed by the energy system (Office of Energy Justice and Equity, 2022). While energy justice and energy equity are closely related and often interchangeably used, energy justice encompasses a broader range of issues, including the remediation of past harms and the inclusion of marginalized communities in decision-making processes. Therefore, energy justice can be seen as a more comprehensive framework that includes energy equity as one of its key components (Initiative for Energy Justice, 2019). The energy security-equity nexus is a framework that examines how the goals of energy security and energy equity interact, sometimes synergistically and sometimes in conflict. Understanding this nexus is essential for creating policies and systems that ensure all people have reliable, affordable, and equitable access to energy.

The reliability of energy systems to meet the demand for electricity from a growing fleet of EVs without compromising the stability and sustainability of the grid is extremely crucial. The transition to electric mobility significantly impacts energy supply and reliability, increasing the load on electrical grids and necessitating the development of more robust, efficient, and flexible power systems. Strategic planning is crucial to enhance grid resilience, incorporate renewable energy sources, and invest in smart grid technologies. This ensures that energy systems are sustainable and can support the widespread adoption of EVs, thereby contributing to the reduction of greenhouse gas emissions and the advancement of clean transportation solutions.

The relationship between energy security and energy equity in the context of the EV transition is multifaceted, involving the availability and accessibility of energy resources. Challenges include ensuring a stable energy supply that can accommodate the increased demand from EVs while making this transition equitable across different socio-economic groups (Carley & Konisky, 2020). Strategies for balancing these objectives include investing in renewable energy to enhance security, and implementing policies that subsidize EV ownership and charging infrastructure for lower-income populations, thus promoting equity in access to clean transportation technologies (Mohammed, Saif, Abo-Adma, Fahmy, & Elazab, 2024).

A framework consisting of the 3As and 3Rs can be a useful way of explaining how energy security and equity can be met (Hughes & de Jong, The Risks of Global Heating to Energy Systems and Energy Security, 2021). It provides a comprehensive structure to analyze the multifaceted issues associated with adopting electric vehicles (EVs). The 3As include availability, affordability, and acceptability. Availability refers to ensuring there is enough energy supply to meet demand. This includes diversifying energy sources and securing long-term energy supplies. Affordability refers to keeping energy prices stable and manageable for all consumers. This will ensure that everyone has access to the energy they need without financial strain. Acceptability refers to ensuring that energy policies and projects are socially and environmentally acceptable. This includes addressing public concerns, engaging communities in decision-making processes, and minimizing environmental impacts. Some frameworks also include accessibility as a key component of energy security. Accessibility refers to making energy accessible by addressing the barriers to energy supply which can be various economic and geopolitical

factors due to technology advancements. The 3Rs are reduction, replacement, and restructuring. Reduce refers to decreasing overall energy demand through efficiency measures and behavioral changes. This can involve policies promoting energy conservation, technological innovations that improve energy efficiency, and public awareness campaigns. Nova Scotia's transition to EVs can leverage policies that encourage energy-efficient driving habits, such as eco-driving programs and incentives for using more energy-efficient EV models. This contributes to overall reduced energy consumption. Replacement involves changing something in the energy system to make it more efficient or use a different energy source. For example, switching from a conventional vehicle to a hybrid-electric vehicle or using biomass instead of coal in a power plant. It means either keeping the same process but changing what powers it or changing the process itself while still using the same energy source. In the thesis, Nova Scotia's policies that support the replacement of traditional ICE vehicles with EVs and plug-in hybrids will be discussed. This includes examining incentives, subsidies, or rebates targeted at making EVs affordable for a broader population. Restructuring refers to completely overhauling part of the energy system, both changing the process and the type of energy used. For instance, shutting down coal power plants and using natural gas or renewables instead. It can also mean adding new processes or services to meet increased demand like people choosing electric vehicles over gasoline ones. This could include carbon pricing, emissions caps, and restrictions on new fossil fuel developments. From Nova Scotia's perspective, this can assess how the province is restructuring its energy system to support the shift to EVs. This includes investments in renewable energy sources (like wind, solar, or hydroelectric) to ensure the grid can sustainably handle the increased electricity demand from EVs. It can also help to examine the efforts toward modernizing the grid infrastructure to support EV adoption, such as upgrading the grid to handle higher loads and incorporating smart grid technologies. Understanding and addressing the energy security-equity nexus through the lens of the 3As and 3Rs framework allows for the development of more holistic and just energy policies, ensuring that the benefits of energy systems are shared widely and sustainably.

1.3 The Energy Security-Equity Nexus

The Energy Security-Equity Nexus is a framework that examines the intersection between energy security and energy equity, recognizing that the two are deeply interconnected and often influence each other. Energy security refers to the uninterrupted availability of energy sources at an affordable price [REF]. It encompasses the reliability of energy supply, the resilience of the energy infrastructure, and the ability to meet current and future energy demands. In the context of transitioning to renewable energy sources or technologies like Electric Vehicles (EVs), energy security involves ensuring that the energy infrastructure can support new forms of energy consumption without compromising the stability and reliability of energy delivery. Energy equity, on the other hand, is concerned with the fair distribution of energy resources and services across different segments of society. It ensures that all individuals and communities, regardless of socio-economic status, geographic location, or other demographic factors, have access to affordable, reliable, and sustainable energy. Equity also involves addressing disparities in energy access that may arise due to income differences, regional disparities, or other forms of social inequality. The nexus between energy security and equity recognizes that achieving one without the other can lead to imbalances and unintended consequences. For instance:

Energy Security without Equity: If a society focuses solely on energy security by ensuring a stable and reliable energy supply but neglects equity, certain groups may be excluded from accessing these energy benefits. This could result in a scenario where the energy infrastructure is robust, but only wealthier or urban populations can afford or access the energy, leading to social inequities.

Energy Equity without Security: Conversely, if the emphasis is solely on equity, ensuring that everyone has access to energy, but without a secure and reliable energy supply, the entire system may become unstable. For example, in efforts to make energy affordable for all, if the infrastructure becomes overstretched or unreliable, everyone's access to energy could be jeopardized, leading to widespread energy insecurity.

In the transition to Electric Vehicles (EVs), the energy security-equity nexus is crucial. As the demand for electricity increases with more EVs on the road, ensuring that this demand can be met without compromising the reliability of the energy supply is essential for energy security. Simultaneously, equitable access to EVs and related infrastructure (like charging stations) must be ensured so that all segments of the population, including low-income and rural communities, can benefit from the transition. The following are some of the points of intersection of energy security and equity.

Infrastructure Development: The development of EV charging infrastructure must be widespread and inclusive, ensuring that both urban and rural areas have access to reliable energy for EVs. This impacts both energy security (through reliable infrastructure) and equity (through widespread access).

Policy and Incentives: Government policies aimed at promoting EV adoption must consider both security and equity. Subsidies or incentives should be designed to make EVs accessible to all socio-economic groups, ensuring equitable access while also supporting the overall stability of the energy system.

Sustainable Energy Transition: The move towards renewable energy sources to power EVs is another area where security and equity intersect. A sustainable transition helps maintain energy security while also addressing environmental justice and ensuring that all communities benefit from cleaner energy.

Overall, the energy security-equity nexus highlights the need to balance and integrate energy security and equity considerations in policy and planning, particularly in transformative transitions like the adoption of Electric Vehicles. This ensures that the benefits of such transitions are shared widely and sustainably across all segments of society.

1.3.1 The current state of the energy security-equity nexus in Nova Scotia

Nova Scotia appears to be at a stage where neither energy security nor equity is fully achieved. The infrastructure to support EVs is still developing, and there are gaps in access and affordability that affect equity.

Energy Security: The energy security of the province's transition to Electric Vehicles (EVs) is being tested due to the increasing electricity demand that EVs bring. The current state may reveal a situation where energy security is somewhat compromised due to a lack of sufficient infrastructure to support widespread EV adoption.

Energy Equity: In Nova Scotia, there are disparities in how different communities experience access to energy, especially when considering the adoption of new technologies like EVs. The current state could reflect inequities in terms of who can afford EVs, who has access to charging infrastructure, and who benefits from government incentives.

1.3.2 The Ideal State of the Nexus

The ideal scenario would be one where Nova Scotia has a robust, sustainable, and resilient energy infrastructure capable of supporting widespread EV adoption without compromising the reliability or

affordability of energy. This includes having ample charging stations, a grid that can handle increased demand, and ensuring that all communities, including marginalized ones, have equal access to the benefits of EVs. The government would aim to create a balanced approach that simultaneously strengthens energy security (through reliable, sustainable energy supply) and promotes energy equity (ensuring everyone has access to these benefits). Following are some of the ways that can help the government to get to the ideal state of the nexus.

Policy and Incentives: The government must implement policies that encourage the uptake of EVs, such as subsidies, tax incentives, and grants for both individuals and companies. These policies would aim to make EVs more affordable and accessible to a broader population, addressing the equity aspect.

Infrastructure Development: This includes expanding the network of charging stations across the province, especially in rural and underserved areas, to ensure that energy security is maintained and all populations can benefit from EV adoption.

Public Awareness Campaigns: This refers to Educating the public on the benefits of EVs, the availability of incentives, and how they can contribute to a more sustainable energy future. This can also involve promoting equitable access to EVs and their benefits across all demographics.

Measurement and Indicators: The progress towards achieving the energy security-equity nexus can be measured using indicators like the number of EVs on the road, the availability and public accessibility of charging infrastructure, the affordability of EVs, and the reduction in greenhouse gas emissions. Regular assessment of these indicators will help in evaluating whether the nexus is being achieved.

These steps underscore the need for a comprehensive indicator framework to track progress and ensure that the government's initiatives are effectively moving towards achieving the energy security-equity nexus. By continuously measuring and assessing these indicators, policymakers can make informed decisions to adjust strategies as needed, ensuring that the transition to electric vehicles is both sustainable and inclusive.

1.4 Objectives

This thesis has two objectives. First, it aims to develop a comprehensive indicator framework for evaluating progress toward EV adoption within a specific jurisdiction, leveraging insights from regions such as California to identify key indicators of successful EV implementation. Second, the indicator framework will be applied to Nova Scotia, offering critical insights to enhance the province's EV adoption strategies and policies. By establishing these benchmarks, the thesis seeks to provide a framework that can guide Nova Scotia in its efforts to accelerate the transition to electric mobility, aligning with global sustainability goals.

The thesis is structured to first provide a background on energy security and vehicle electrification, followed by a comprehensive literature review that systematically analyzes the body of existing research focusing on theories, models, current trends, and methods related to energy security. It then introduces a detailed methodology for evaluating a jurisdiction's progress in implementing EV policies, using California as a benchmark for comparison. The case study section applies a developed set of indicators to assess Nova Scotia's progress toward widespread EV adoption, offering insights into the province's current state, achievements, and areas for policy enhancement. These sections are designed to build upon each other, culminating in a set of actionable recommendations for Nova Scotia's EV adoption strategy.

2. LITERATURE REVIEW

This literature review systematically examines the body of existing research focusing on models, current trends, and methods related to energy security and equity in the context of electric vehicle (EV) adoption. The section will highlight theories supporting research, their applications, and recent findings on inequality among low-income communities. It aims to provide a comprehensive understanding of how EV adoption intersects with issues of energy security, equity, and environmental justice.

2.1 Equity, Environmental Justice, and EV Adoption

Addressing the challenges and opportunities of EV adoption requires a thorough understanding of equity and environmental justice, access to EVs and charging infrastructure, and the global impacts of this transition. The following sections delve into these critical aspects.

2.1.1 Theories of Equity and Environmental Justice

Theories of equity and environmental justice are crucial to the discussion of EV adoption. These theories emphasize fair and equitable access to the benefits of clean energy technologies and highlight how historical inequalities can be exacerbated by new technological developments if not adequately addressed. Research indicates that plug-in electric vehicle (PEV) buyers are not socio-economically or ethnically representative of the population. PEV consumers are mostly male, high-income, highly educated, homeowners, with access to home charging (Hardman et al., 2021). For instance, in California, PEV buyers have an annual median income of USD 190,000, with 81% being homeowners and 75% male. Such demographic trends depict the contemporary PEV market as predominantly white and high-income (Bauer et al., 2021).

2.1.2 Access to EVs and Charging Infrastructure

Access to EVs and charging infrastructure is often unevenly distributed, with lower-income and marginalized communities facing significant barriers. These barriers include the upfront costs of EVs, the lack of charging infrastructure in certain areas, and the digital divide affecting access to information and technology (Hsu & Kevin, 2021). Additionally, uncertainty about the resale value of EVs and financing challenges exacerbate these issues (Hardman et al., 2021). For example, the temporary loss of US EV tax credit eligibility for certain vehicles has increased the volatility of incentives, affecting the long-term value of EV investments, particularly for individuals with limited financial resources (Shepardson, 2024).

2.1.3 Environmental Justice and Global Impacts

The environmental justice perspective also considers the global dimensions of EV adoption, especially the impacts of mining for critical minerals on local communities and ecosystems in resource-rich countries. Ensuring that the transition to EVs does not replicate the injustices associated with fossil fuel extraction requires a commitment to responsible sourcing, community engagement, and environmental protection.

2.2 Models of EV Adoption and Their Impact on Energy Systems

The Diffusion of Innovation theory, formulated by Everett Rogers in 1962 (Miller, 2015) **,** provides a framework for understanding how, why, and at what rate new ideas and technology spread through cultures (Singhal, Rogers, & Quinlan, 2019). When applied to the adoption of EVs, this theory helps dissect the complex interplay of factors influencing their market penetration and societal acceptance. This analysis further extends to examining the role of Integrated Assessment Models (IAMs) in evaluating the implications of widespread EV adoption on energy systems, carbon emissions, and policymaking.

2.2.1 Diffusion of Innovation Theory

Understanding the factors that drive the adoption of EVs is essential for fostering their widespread acceptance. The following sections discuss the Diffusion of Innovation Theory, the role of policy in influencing EV adoption, and the importance of infrastructure development in this process:

Innovators and early movers: The early stages of EV adoption are driven by innovators and early movers who are more willing to take risks and are more environmentally conscious. This group is important in the diffusion process because it provides the first market for EVs, helping to demonstrate the viability and benefits of electric mobility to a wide audience (Singhal, Rogers, & Quinlan, 2019).

The role of policy in influencing EV adoption: Government policies play an important role in accelerating the spread of EVs. Incentives such as tax credits, grants for EV purchases, and investment in research can lower initial barriers to adoption. In addition, policies aimed at increasing the cost of owning gasoline-powered vehicles, such as carbon pricing, can make electric vehicles more economically attractive (Rapson & Muehlegger, 2021).

Infrastructure Development: The availability and public accessibility of charging infrastructure are critical to the EV adoption curve. As the infrastructure becomes more widespread and affordable, the practice of EV ownership increases, encouraging the majority to begin to consider and eventually adopt EVs. This stage is critical for marketers starting to transition to the mass market.

2.2.2 Integrated Assessment Models (IAMs)

An Integrated Assessment Model is a tool that integrates knowledge from multiple disciplines to assess the impacts of complex issues such as climate change, energy system changes, and policy interventions. This is particularly useful for understanding the broader impact of EV adoption on energy systems, carbon emissions, and policy decisions. Integrated Assessment Models (IAM) are essential tools for understanding and addressing the multifaceted impacts of electric vehicle (EV) adoption. They provide comprehensive analyses in several key areas:

Impact on Energy Systems: IAM can estimate the increased demand for electricity as a result of widespread EV adoption and assess the ability of current and future energy systems to meet this demand. The model helps plan the necessary improvements to power generation, transmission, and distribution infrastructure to support EVs while maintaining energy security and reliability (Figenbaum & Kolbenstvedt, 2016).

Reducing Carbon Emissions: IAM plays an important role in determining the carbon emission reduction potential of replacing internal combustion engine vehicles with EVs (Chu & Majumdar, 2012). By considering factors such as the mix of energy sources used to generate electricity, IAM can better understand the clean environmental benefits of EV adoption in different scenarios.

Informing policy decisions: IAMs provide insight into the effectiveness of various policy measures in promoting EV adoption and achieving environmental goals. It can help policymakers understand the trade-offs and synergies between different policy options, such as incentives for EV purchases, investments in charging infrastructure, and regulations to phase out gasoline-powered vehicles (Government of Canada, 2022).

The adoption of EVs is a multifaceted process influenced by technological innovation, policy intervention, infrastructure development, and community acceptance. Innovation theory provides a valuable framework for understanding this process and identifying strategies to accelerate the transition to electric mobility. At the same time, the integrated evaluation model plays an important role in assessing

the wider consequences of EV adoption, helping policymakers and stakeholders make informed decisions to support this transition. Together, these tools offer a comprehensive approach to understanding and facilitating the transition to a more sustainable and low-carbon transport future.

2.3 Current Trends in Research on the Energy Security-Equity Nexus

The adoption of EVs is a critical component of the global shift towards sustainable transportation, with significant implications for energy security, equity, and environmental sustainability. Recent studies have highlighted various aspects of EV adoption, focusing on geographic, socioeconomic, and policy variables, and the effectiveness of policies aimed at promoting EV adoption through incentives, infrastructure development, and regulatory measures (Hardman, Fleming, Khare, & Ramadan, 2021). Examining the broader implications of EV adoption involves considering its impact on energy security and equity, addressing equity concerns in incentive structures and access, and understanding geographic disparities in EV adoption. The following sections provide an in-depth analysis of these critical issues.

2.3.1 Impact of EV Adoption on Energy Security and Equity

The transition to EVs significantly affects energy consumption patterns. A study published by Powell et al., examined the grid impacts under different EV charging scenarios, revealing that EV adoption could increase annual electricity consumption by up to 28% over 2019 levels in a scenario of 100% EV adoption (Powell, Cezar, Min, Azevedo, & Rajagopal, 2022). As Greg Craig, CEO of Griddy, a wholesale electricity provider in Texas, stated, “The biggest challenges for the grid with the widespread adoption of EVs are two major things: volume and timing of charging. As the overall expectations for the adoption of EVs are massive, that amount of new added demand for electricity will by itself become a challenge for grids all around the world, and for grids that are constrained on transmission and distribution infrastructure” (Proctor, 2020). The timing and method of charging are crucial, with home charging being the most prevalent, contributing to significant spikes in electricity demand during peak hours. This underscores the importance of developing smart charging infrastructure to mitigate grid impacts (Energy your ways, 2023).

Existing grid systems will require upgrades to handle additional loads. This will include automatic equipment replacement, improved transmission lines and the integration of new technologies for better load management. Of course, by the adoption of E-mobility, energy demand would increase but experts have predicted the impact on grid capacity to be large ('Connor, 2017). According to Tom Baker, managing director and partner with Boston Consulting Group, if 15-20% of all the vehicles in a representative utility’s service area are EVs by 2030, about 5-10% increase in energy demand and 25-33% increase in demand for grid capacity is expected. According to him, the actual increase for a specific utility will be highly dependent on the local EV penetration, the charging infrastructure installed, and lastly, the extent to which EV charging happens when the grid is already constrained (Proctor, 2020).

2.3.2 Equity Concerns in EV Adoption

Equity issues in EV adoption have been prominent, particularly regarding incentive structures and access to charging infrastructure. Non-targeted incentives for electric vehicles can unintentionally become a barrier to adoption in disadvantaged communities due to a variety of factors (Hsu & Kevin, 2021). While incentives are generally aimed at promoting the adoption of cleaner and more sustainable transportation options, certain aspects of non-targeted incentive programs may create disparities (Hardman, Fleming, Khare, & Ramadan, 2021).

Purchase incentives typically include financial payments to car buyers for the purchase or lease of a PEV. The US federal PEV incentive offers an income tax credit of up to US $7,500 for new PEV purchases. To receive the full $7,500 credit, consumers need to earn more than US $66,000 per year for single filers and US $91,000 for dual filers (Doll, 2024). Low-income consumers receive less credit, meaning lower-income households receive less than higher-income households. The incentive is also received after the PEV purchase, meaning the buyer is still required to fund the entire PEV purchase price. In contrast, the recently introduced California Clean Fuel Reward is distributed at the point of sale but does not distribute incentive funds equally. For example, a buyer of a US $70,000 Lincoln Aviator PHEV gets a 33% higher incentive than a buyer of a US $28,990 Prius Prime, which is not only a lower-cost vehicle but also more efficient and has a longer electric driving range. Additionally, the program applies only to new PEVs, is available only at select dealerships, and has no purchase price or income limits (Bauer, Hsu, Nicholas, & Lutsey, 2021).

California, Oregon, and Pennsylvania are examples of states that have incorporated equity aspects into PEV incentives to address the needs of low-income individuals or those living in air-polluted districts or disadvantaged communities. Oregon offers up to US $2,500 toward the purchase of a new PEV, with an additional US $2,500 incentive upfront for low- or moderate-income families (Electrify, 2023). CARB introduced revenue limits and MSRP caps intended to provide incentives to those who need them most (Electrify, 2023). In Pennsylvania, low-income buyers receive an additional US $1,000 rebate on top of the US $750 rebate for BEVs (Electrify, 2023). While these programs are progressive, they focus on rebates for new vehicle buyers who comprise only one-third of all car buyers (Electrify, 2023).

2.3.3 Geographic Disparities

The geographic disparity in EV adoption, especially between urban and rural areas, is a significant challenge. Rural areas, which cover most of the U.S. land area, lack adequate charging infrastructure, creating a barrier to EV adoption (Hardman, Fleming, Khare, & Ramadan, 2021). There is a larger concentration of public charging infrastructure in wealthier neighborhoods compared to disadvantaged communities and low-income neighborhoods (Hardman, Fleming, Khare, & Ramadan, 2021). Black and Hispanic neighborhoods only had 0.7 times the access to public chargers as the no-majority reference group in California. They also determined that even when income, proximity to the nearest highway, and multi-family housing were controlled for, White-majority census block groups were 1.5 times more likely to have access to public charging stations compared to Black- and Latino-majority census block groups (Bauer, Hsu, Nicholas, & Lutsey, 2021). The national average of EV charging stations in Canada is far below the density of gas stations, emphasizing the need for federal investment and initiatives to increase charger density in rural areas (Hardman, Fleming, Khare, & Ramadan, 2021). Electric cooperatives have started playing a role in addressing this gap by installing charging stations in rural communities, thus encouraging EV adoption and contributing to economic development.

2.4 Effectiveness of EV Adoption Policies

To effectively promote EV adoption and achieve environmental and societal health goals, it is essential to consider various strategies including incentives, infrastructure development, and regulatory measures. The following sections explore these critical approaches:

Incentives: Incentives have been crucial in encouraging EV purchases, with programs offering tax credits, rebates, and other financial benefits. Strategies include increasing the supply of used PEVs through leasing, offering point-of-sale incentives with income and purchase price caps, and extending incentives to low-income buyers for used PEV purchases from non-dealership sources (Guo & Kontou, 2021).

Infrastructure Development: The development of EV charging infrastructure is vital for supporting EV adoption. Federal and state investments, especially in underserved rural areas, are essential to overcome range anxiety and facilitate the transition to electric mobility. Policies often provide rebates for installing Level 2 chargers and infrastructure upgrades, with a focus on benefiting disadvantaged communities (Electrify, 2023).

Regulatory Measures: Regulatory measures, such as emission standards and vehicle efficiency requirements, complement financial incentives and infrastructure development efforts. These measures promote EV adoption and ensure that the transition to electric mobility contributes to broader environmental and societal health goals.

2.5 Critical Analysis of Existing Literature

Studying the long-term impact of widespread EV adoption on marginalized communities and the resilience of energy systems is essential to understanding the broader implications of the transition to a sustainable transportation system. This discussion evaluates the areas that have not been thoroughly researched and evaluates the advantages and limitations of the methodology used in existing research.

2.5.1 Unexplored Areas

Research is needed to understand how EV incentives and subsidies can be designed more inclusively. The shift to EVs could affect employment in the traditional auto and oil industries, where marginalized populations are more numerous (Lee & Clark, 2018). Additionally, the impact of EV charging on electricity costs, especially for low-income households, remains largely unexplored (Hsu & Kevin, 2021).

Comprehensive studies are required to understand the long-term effects of widespread EV adoption on grid capacity and stability. Research should also explore how EVs can support the integration of renewable energy sources into the grid and the cybersecurity risks associated with increased connectivity (Kumar & Alok, 2020; 'Connor, 2017).

2.5.2 Methodologies in Existing Research

Understanding the impacts of EV adoption requires a multi-faceted approach, including quantitative models, case studies, and policy analyses. Each method offers unique insights and has its own limitations.

Quantitative models are powerful tools for predicting the impacts of EV adoption but often rely on assumptions that may not accurately reflect real-world complexities. They may also struggle to capture socio-economic and behavioral factors affecting EV adoption and usage. Case studies provide in-depth insights into specific contexts but may not be generalizable to other contexts. They can highlight unique issues and innovative solutions but might overlook broader trends and patterns. Policy analyses are crucial for understanding the regulatory and economic environment influencing EV adoption. However, they may not fully account for the unintended consequences of policies and can be biased by the political and ideological perspectives of the researchers.

2.6 Research Gaps and Bridging the Gaps

Despite extensive research on EV adoption, significant gaps remain in understanding the intersection of energy security, equity, and EV infrastructure development. This research aims to bridge these gaps by:

Focusing on Equity Issues: This research will delve into how EV adoption policies impact marginalized communities, examining barriers to access, financial challenges, and the distribution of benefits. By incorporating socio-economic analyses and community perspectives, the study will provide insights into designing more inclusive and equitable EV policies.

Developing Inclusive Incentive Programs: The research will analyze the effectiveness of current incentive programs and propose strategies to make them more accessible to low-income and marginalized communities. This includes exploring income-based incentives, support for used EV purchases, and innovative financing options.

Exploring Geographic Disparities: The study will address geographic disparities in EV adoption, focusing on rural and underserved areas. It will investigate the role of local policies, federal investments, and public-private partnerships in expanding charging infrastructure and promoting EV adoption in these regions.

2.7 Chapter Summary

This literature review highlights the complex interplay of factors influencing EV adoption, including theories of equity and environmental justice, diffusion of innovation, and integrated assessment models. Current trends in research emphasize the significant impacts of EV adoption on energy security and equity, with particular attention to geographic and socio-economic disparities. The review also critically analyzes existing methodologies and identifies unexplored areas that require further research to ensure a just and equitable transition to electric mobility. Addressing these challenges comprehensively can harness the full potential of EVs to contribute to a more sustainable, fair, and reliable energy future.

3. METHODOLOGY

This chapter will play a critical role in evaluating EV policies in jurisdictions. To develop a comprehensive framework for assessing the efficacy of jurisdiction-level EV policies, this chapter must lay out a clear and detailed set of indicators. The three key components of this framework include the rationale behind the selection of these indicators, the criteria that were used to identify them, and the method by which they will be operationalized. To accomplish this, the chapter is structured into three distinct sections: Objectives, Indicator Selection Criteria, and Indicator Descriptions. It will serve as a blueprint for conducting the case study analysis on Nova Scotia, with California as a benchmark for comparison.

3.1 Objectives

The following is the set of objectives of this methodology with their description. These objectives synthesize broad themes frequently discussed in academic literature, policy analysis frameworks, and sustainability assessment tools. To ensure they are comprehensive and align with current research and practices, the objectives are informed by current best practices in policy evaluation and infrastructure development as documented in case studies, pilot projects, and benchmarking studies from leading jurisdictions in EV adoption, such as California and several European countries. Moreover, these objectives consider the need for the methodology to be adaptable to different jurisdictional contexts and scalable from local to national levels, aligning with approaches used in comparative policy analysis (Lucas, et al., 2018).

Establishment of a Comprehensive Indicator Framework: The primary objective is to create a comprehensive set of indicators covering the multifaceted dimensions of EV policy implementation. These indicators will include aspects such as policy development and implementation, infrastructure readiness and expansion, market penetration of EVs, and inclusiveness and equity of EV initiatives. In doing so, the methodology aims to provide an overview of jurisdictions' EV adoption efforts and performance.

Assessment of Policy Implementation and Effectiveness: Another objective is to assess the effectiveness of policies adopted by jurisdictions to promote EV adoption. This includes an analysis of policy frameworks, incentives, and regulatory measures implemented to support EV infrastructure development, consumer adoption, and integration of EVs into energy networks. The methodology will assess the fairness and foresight of these policies, their implementation, and real-world effects.

Evaluation of Infrastructure Development: Another key objective is to examine the development and availability of EV charging infrastructure, which is essential to support EV adoption. This involves evaluating the density, distribution and availability of charging stations, as well as the readiness of the electricity grid to accommodate the increasing load from EVs. The methodology will consider urban and rural equity in infrastructure development to ensure a balanced transition in different areas.

Analysis of Market Penetration: This objective aims to assess factors such as market penetration of EVs in certain jurisdictions, sales trends, market share relative to internal combustion engines, and the diversity of EV models available. It will also highlight any differences in adoption rates due to the availability and affordability of EVs for different socioeconomic groups.

Inclusivity and Equity Considerations: An important objective of the methodology is to assess the equity results of EV policies and infrastructure development. This includes evaluating whether policies

and infrastructure are inappropriate or disadvantage specific communities, especially marginalized and low-income groups. The methodology aims to ensure that the transition to EVs is inclusive, addressing potential barriers to adoption and adopting measures to reduce negative impacts.

Comparative Analysis across Jurisdictions: Finally, the methodology allows comparative analysis of jurisdictions, helping to understand best practices and areas for improvement. By applying a set of indicators developed for different jurisdictions, the methodology will provide insight into the effectiveness of different approaches to EV adoption and the extent to which they promote energy security and equity.

3.2 Selection of Indicators

The selection of indicators is pivotal in this process as they provide the benchmarks against which progress can be assessed. These are the indicators that will be used in this methodology to assess any jurisdictions' EV progress. See Table 1.

Table 1 Indicators for EV transition Assessment

INDICATORS	METRICS
Policy Implementation	Legislative Support and Subsidies, Emissions regulations, Energy Policies, Education and Awareness Programs
Energy Infrastructure Development	Charging Infrastructure Availability, Electric Grid Capacity and Reliability
Market Penetration	EV Sales, Number of EV Chargers
Equity Consideration	Economic Inclusivity, Infrastructure Distribution, Workforce Development

The following is a detailed discussion of the selection criteria for these indicators, emphasizing their relevance to energy security and equity, measurability, availability of data, and comparative utility.

Relevance to Energy Security and Equity: Indicators should be directly related to the jurisdiction's ability to maintain a stable and consistent supply of energy for EVs. These include the ability to produce renewable energy and the resilience of energy infrastructure. Moreover, they should also relate to the affordability of EVs ensuring that EVs are within the economic reach of a broad segment of the population. Indicators should also measure how the benefits and burdens of the transition to electric vehicles are distributed among different segments of the population. This includes assessing the availability of EV charging infrastructure, the availability of electric vehicles, and the impact of EV policies on low-income and marginalized communities.

Measurability: Indicators should be quantitative to allow objective evaluation and comparison. This involves choosing clear indicators, operational definitions and defined measurement methods. For example, the number of public charging stations per capita or the percentage of renewable energy in the total energy mix for EVs is defined and can be measured consistently across jurisdictions.

Availability of Data: The feasibility of conducting the evaluation significantly depends on the availability of reliable and up-to-date data. Therefore, the choice of indicators should consider the ease of access to quality data. This may include state government reports, industry publications and international databases. Indicators where data is collected regularly and made available to the public should be prioritized to ensure the continuity of the evaluation process.

Ability to Facilitate Comparisons between Jurisdictions: For the case study involving Nova Scotia and California, indicators should be chosen with a view to their comparative utility. This means choosing appropriate indicators for different regulatory, geographic and socio-economic contexts. Indicators should allow meaningful comparisons between jurisdictions, showing progress and areas for improvement. This includes standardization of indicators, or whether they can be adjusted to account for differences in population, economic output, and other relevant factors.

3.3 Description of Indicators

To assess a jurisdiction's progress in the EV transition, it is important to develop a comprehensive set of indicators. These indicators serve as benchmarks to assess the effectiveness of EV policies, necessary infrastructure development, EV market penetration, and equity considerations during the transition. It provides a structured way to measure jurisdictional compliance with the adoption and promotion of electric vehicles, to identify areas of success and those in need of improvement. By grouping these indicators into Policy Implementation, Infrastructure Development, Market Penetration, and Equity Considerations, an overview of the jurisdiction's progress can be obtained. Each of these areas encompasses both quantitative and qualitative metrics, which requires a blended approach to measurement. Table 2 shows each indicator's respective metrics being into divided into qualitative and quantitative measures.

Table 2 Indicators with their qualitative and quantitative measures

	Policy Implementation	**Energy Infrastructure Development**	**Market Penetration**	**Equity Considerations**
Quantitative Measures	• Emission Regulations	• Charging Infrastructure Availability, • Electric Grid Capacity and Reliability	• EV Sales and Market Share	• Economic Inclusivity • Infrastructure Distribution
Qualitative Measures	• Energy Policies, • Education and Awareness Programs, • Legislative Support and Subsidies	• Strategic Placement of charging stations	-	• Workforce Development

To assess the progress of the EV transition in different jurisdictions, it is important to use a set of metrics that can effectively measure both qualitative and quantitative aspects of the transition. While qualitative measures are mainly focused on the policies that are implemented in different jurisdictions, they can still be evaluated to determine their effectiveness. On the other hand, quantitative measures can be monitored and assessed numerically, and results can be visually represented in the form of graphs, which can help to illustrate the relationship between each indicator and the level of EV adoption in the jurisdiction.

3.3.1 Policy Implementation

The Policy Implementation indicator provides a crucial lens through which to evaluate Nova Scotia's progress in transitioning to EVs. For a proper evaluation of any jurisdiction, metrics for every indicator need to be created so that the progress of any jurisdiction can be truly tested and compared. First, the metrics for policy implementation will be made to prepare a sample that can be applied to Nova Scotia to assess the province's progress. To develop metrics for the "Policy Implementation" indicator, we have broken down each factor (legislative support and subsidies, emissions regulations, energy policies, and education and awareness programs) into manageable groups of metrics. Emission regulations and energy policies that encourage the replacement of fossil fuels with renewables are key indicators. Legislative support and subsidies that target the replacement of old technologies with new ones can ensure that energy equity is maintained during this transition. These metrics will help assess the progress and effectiveness of policy implementation.

3.3.1.1 Legislative Support and Subsidies

The metrics for this factor focus on the legal and financial frameworks supporting EV adoption. Tracking the number of laws and financial incentives provides insight into government commitment. The following are the metrics developed for the thesis to be used to assess legislative support and subsidies of a jurisdiction:

Number of EV-related legislations passed: Track the number of laws and regulations specifically supporting EV adoption.

Financial incentives available: Quantify the subsidies and tax incentives provided for purchasing EVs and installing charging infrastructure

Budget allocation for EV initiatives: Measure the amount of funding allocated in the provincial budget for EV programs and initiatives.

California provides several legislative supports and subsidies to encourage EV adoption and the transition to a zero-emission future. Various local incentives include rebates for buying or leasing used EVs, scrapping programs for old, polluting vehicles, and rebates for new or used Battery-Electric vehicles. For example, Riverside Community Services offers a rebate of up to $1,000 for electric cars purchased or leased after January 1, 2023 (Electrify Riverside, 2023). Southern California Edison offers a $1,000 rebate for used EVs. Other programs offer similar incentive offers in various neighborhoods and community services (Southern California Edison, 2024). The program, Clean Cars 4 All, offers $9,500 to low-income drivers who trade in their polluting vehicles for older, dirtier, cleaner, and more efficient models. Eligibility for the program and the amount of the incentive depends on household income, place of residence and the chosen replacement vehicle (Southern California Edison, 2024).

When it comes to tax credits and grants, California's 2022-23 budget includes significant funding to expand existing programs and create new programs aimed at accelerating ZEV adoption. Key components include federal funding and funding for ZEV infrastructure through a competitive grant to replace non-electric with electric school buses ($1.5 billion), an EV charging infrastructure grant ($600 million), and the Infrastructure Investment and Projects Act ($383 million) (Legislative Analyst's Office, 2022). In addition, California has given a historic $10 billion to accelerate the transition to ZEVs. The package supports a wide range of initiatives, from community-based transport equity projects to investments in high-carbon sectors such as maritime and aviation. The goal is to make electric cars more accessible and affordable, especially for low-income communities (California Energy Commission, 2024). The California Energy Commission has launched a $38 million project aimed at expanding EV charging in

low-income and vulnerable communities. The cost of charging equipment can cover up to 50 percent of the total project cost, or up to $100,000 (CEC, 2023).

As part of a $10 billion investment package for EV research and development in California, $200 million has been earmarked for demonstration and pilot projects in high-carbon industries, as well as large-scale transportation network integration. These funds are intended to establish California's ZEV market and maintain its role as a center of innovation. $419 million to support community-based transportation projects that increase access to zero-emission mobility in low-income communities. This includes clean mobility options and sustainable transport projects developed by the community (Office of Governer Gavin Newsom, 2022).

California's legislative support and EV subsidies have had a significant impact on EV adoption over time, acting as a catalyst for EVs to become more widely adopted and marketed. A key finding by the NBER shows the price elasticity of demand for EVs among low- and moderate-income households, suggesting that subsidies have a direct impact on EV adoption rates. The study found that with subsidies passed on to buyers, the demand for EVs is price elastic, with financial incentives directly lowering the purchase price for consumers and encouraging adoption. However, the study also noted the financial commitment needed to meet California's ambitious EV adoption goals, estimating that subsidy bills could cost $12-18 billion to reach 1.5 million EVs by 2025 (CARB, 2022).

California's legislative support and subsidies have been instrumental in driving EV adoption, demonstrating the effectiveness of comprehensive policies that address cost barriers for consumers and infrastructure needs for widespread EV adoption. These efforts contribute to California's EV market leadership and progress toward ambitious environmental and public health goals.

Strong legislative frameworks ensure the long-term commitment of resources and policies towards sustainable energy, which enhances energy security. Also, financial incentives for EV adoption reduce oil dependency and boost energy security. Legislation can include provisions that specifically address the needs of low-income or rural communities, ensuring equitable access to EVs and related infrastructure. Moreover, the subsidies make EVs more affordable for low-income individuals, addressing economic disparities in access to clean transportation. Considering both of these aspects together, an ideal state for energy security-equity nexus can be achieved.

3.3.1.2 Emissions Regulations

The metrics for this factor should assess how stringent and effective emissions regulations are in driving the shift to EVs. Following are some of the metrics developed for the thesis that can be used to assess emissions regulations of a jurisdiction:

Stringency of emissions standards: Evaluate the strictness of emissions regulations for vehicles, focusing on how they encourage a shift to EVs.

Compliance rates with emissions targets: Measure the percentage of vehicles meeting the emissions standards.

Penalties and enforcement actions: Track the number of penalties or enforcement actions taken against non-compliance with emissions regulations.

California has implemented emissions regulations and policies to support the adoption of EVs and reduce emissions from conventional internal combustion engine vehicles. These measures are designed to make electric vehicles more attractive, making gasoline-powered vehicles more fun to own and operate. The CARB has created comprehensive Clean Car II regulations aimed at rapidly reducing emissions from

passenger cars, trucks and light commercial vehicles from 2026 to 2035 (CARB, 2022). The aims of this regulation are twofold:

- ZEV Requirement: Part of this Regulation amends the existing ZEV Regulation to require car manufacturers to sell a certain number of zero-emission vehicles from 2026 to 2035, to achieve 100% new ZEV sales (CARB, 2022). See Figure 3. These include battery-electric, hydrogen fuel cell electric and plug-in hybrid electric vehicles. By 2030, this rule aims to decrease the number of new gas-powered cars sold by 2.9 million and by 2035 to 9.5 million fewer conventional vehicles (CARB, 2022).

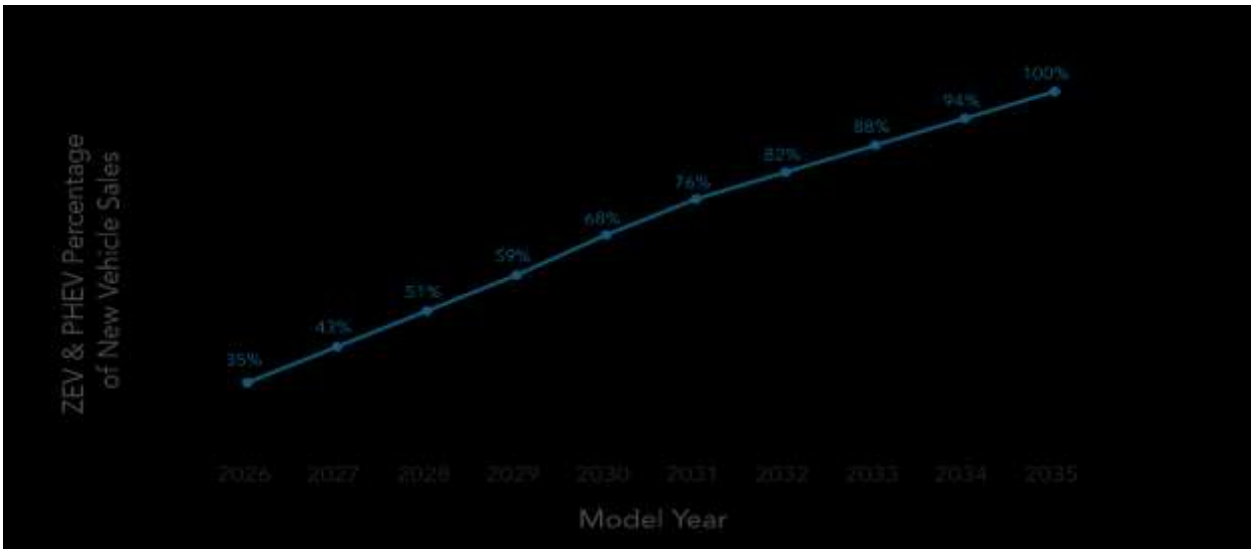

Figure 3 Percentage of ZEVs and PHEVs out of the total new vehicle sales in California (California Air Resource Board, 2022)

- Low Emission Vehicle (LEV) Standards: This section amends existing regulations to include stricter standards for gasoline-powered cars and heavier passenger cars to reduce smog-forming emissions further. The goal is to reduce air pollutants that threaten public health and contribute to climate change. This is expected to reduce GHG by more than 35% and reduce nitrogen oxide emissions by 80% (CARB, 2022). Although more than a dozen states have set goals to ban the sale of gas-guzzling cars, California is the first state in the United States to take this stance (CARB, 2022).

California plans to achieve net zero carbon emissions by 2045 and will be the first state to set a comprehensive road map for carbon neutrality. These goals span many sectors, including energy, transportation, agriculture, and natural resource management, to reduce the negative impacts of climate change, improve health outcomes, and stimulate investment and public employment (CAgov, 2022). California's leadership in setting strict vehicle emissions standards has encouraged other states to adopt similar or identical standards. To date, 17 states have adopted all or part of California's low-emission and zero-emission vehicle regulations, expanding support for the clean vehicle market in the United States (CAgov, 2022). This effort has yielded tangible results. California has seen significant growth in EV sales, a growing network of EV charging infrastructure, and significant reductions in emissions from the transportation industry (Mihalascu, 2023). These policies and regulations not only reduce the environmental impact of transportation but also serve as a model for other countries and countries that want to curb vehicle emissions and promote the adoption of electric vehicles.

By imposing stricter emission regulations, the government can encourage the transition to cleaner energy sources, thus reducing dependence on fossil fuels and enhancing energy security. However, this also needs to be ensured that low-income communities are not disproportionately affected by pollution, as these regulations can help mitigate environmental justice issues. In this way, a proper balance between energy security and equity can be maintained.

3.3.1.3 Energy Policies

Metrics in this category should evaluate the alignment of energy policies to support EVs through renewable energy integration and grid readiness. Following are some of the metrics developed for the thesis that can be used to assess the energy policies of a jurisdiction:

Renewable energy targets: Assess the targets set for renewable energy integration in the electric grid.

Progress towards renewable energy goals: Measure the percentage of electricity used for EVs that comes from renewable sources.

Incentives for renewable energy: Quantify the incentives provided for renewable energy projects that support the EV transition.

California has taken significant steps to support EVs and integrate renewable energy sources into the national grid to reduce its carbon footprint, demonstrating its commitment to a clean transportation future. Policies and initiatives are aimed at ensuring grid reliability, availability and resilience while promoting the adoption of EVs. Governor Newsom outlined California's vision for a clean energy transition through "Building the Electric Grid of the Future: California's Clean Energy Transition Plan," highlighting the state's fight against climate change. The plan includes hundreds of solar, wind, battery storage and other clean energy projects. It also emphasizes the importance of technology in modernizing the power grid by allowing users to feed electricity from zero-emission car batteries back into the grid, increasing the efficiency and reliability of the grid (CAgov, 2022).

The CEC plays a critical role in leading the state toward a 100 percent clean energy future. Establish and authorize programs that use renewable energy, encourage the installation of energy technology, and provide renewable energy grants. These efforts include the Clean Energy and Pollution Reduction Act (SB 350), the Electricity Program Investment Cost Program (EPIC), and various initiatives focused on geothermal, offshore wind, and solar energy, which aim to ensure that these benefits reach all Californians (CEC, 2022). The IEPR by the Central Election Commission takes a comprehensive approach to addressing the country's energy needs and challenges. It includes a detailed assessment and analysis of California's energy landscape, including demand, supply, and infrastructure planning implications. This report plays an important role in the development of policies aimed at reducing greenhouse gas emissions, ensuring electricity reliability and supporting the country's economic goals (CEC, 2022).

When it comes to connecting renewable energy to the grid, the transition includes renewable sources of centralized and distributed generation. Centralized utility-scale renewables can be more economically viable due to savings, while distributed renewables offer benefits such as reduced power losses and increased resilience during power outages. The integration of renewable resources requires flexible and efficient grid management methods that adapt to the changing nature of renewable energy sources. Policies and regulations play an important role in creating an environment conducive to EV adoption (Energy Saver, 2023). Developing financial incentives, building and hardware standards for chargers, and regulations on charging infrastructure are important elements. In addition, energy sector regulators set electricity tariffs and determine the utility's role in charging for infrastructure development (Energy

Saver, 2023). This comprehensive approach to policymaking not only supports the transition to EVs but also serves the broader goals of reducing emissions and energy sustainability.

In 2022, California made significant progress in the production of renewable energy as shown in Figure 4. The country's total electricity production is 287,220 gigawatt-hours (GWh), with renewable sources (diesel, wind, biomass, geothermal and small hydro) contributing 102,853 GWh (California Energy Comission, 2023). This represents a 10.2% increase in renewable generation compared to 2021. In particular, solar output increased significantly by 24.1% to 48,950 GW. When accounting for sources of non-GHG emissions, including nuclear and large hydroelectric plants, 54.2% of California's total electrical energy comes from clean energy sources (California Energy Commission, 2023). In addition, the California Energy Commission's 2021 report shows that more than 37% of the state's electricity is generated from Renewable Portfolio Standards (RPS) from reliable sources such as solar and wind. About 59% of California's electricity comes from non-fossil fuel sources and other zero-carbon sources such as hydroelectric power plants and nuclear power. Over the past decade, solar generation in California has increased twentyfold, and wind generation has increased 63%, demonstrating the state's commitment to transition from fossil fuels to a more sustainable and clean energy network (CEC, 2022).

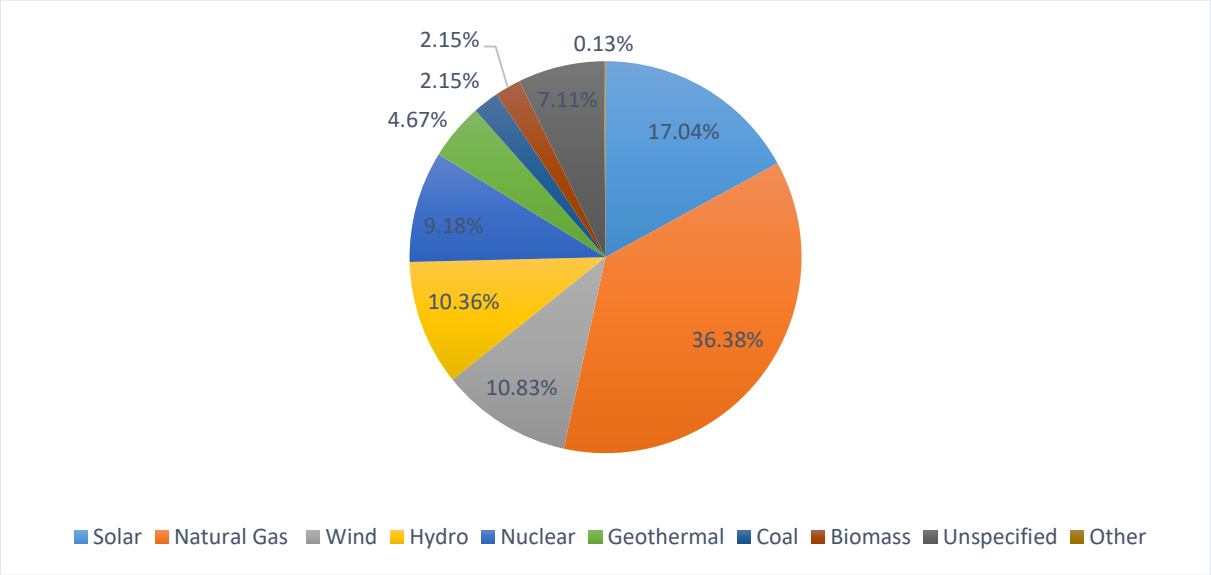

Figure 4: California's Energy Mix 2022 (California Energy Commission, 2022)

The integration of renewable energy sources and support for EV adoption has had a big impact on California. This approach helps develop the EV market, encourages innovation in renewable energy technology, and contributes to the nation's demand for it.

Policies that promote renewable energy and EV adoption help diversify the energy mix, reduce reliance on imports, and ensure a stable energy supply ensuring energy security. However, these policies can be designed to ensure that all communities, including marginalized groups, have access to the benefits of renewable energy and EVs. This can help to achieve an ideal energy security-equity nexus.

3.3.1.4 Education and Awareness Programs

The metrics for this category should measure efforts to raise public awareness and education about EVs, crucial for driving adoption. The following are some of the metrics developed for the thesis that can be used to assess the progress of education and awareness programs of a jurisdiction:

Number of public awareness campaigns: Track the number and reach of public campaigns promoting EV adoption.

EV-related educational initiatives in schools: Measure the inclusion of EV and sustainable transportation topics in school curriculums.

Public engagement events: Count the number and attendance of events like workshops, seminars, and EV expos.

California has implemented various education and awareness programs to support EV adoption, focusing on increasing public awareness of the benefits of EVs. These programs aim to address common misconceptions about EVs, explain the benefits of electric mobility, and create a supportive ecosystem for potential and current EV owners.
Launched by Veloz, the Electricity for All Campaign aims to accelerate EV adoption through consumer tools, resources and educational campaigns (VELOZ, 2024).y station Electric for All offers a comprehensive platform that helps prospective EV owners understand their options, shop and compare electric vehicles, and find driving and charging incentives. Research by the Greenlining Institute has shown the importance of educating consumers about EVs to address common misconceptions about EVs, such as high costs, inadequate charging infrastructure, and practicality. The institute's research emphasizes the need for comprehensive consumer education about the benefits of EVs and arguments against myths about electric transportation (Reichheld, Peto, & Ritthaler, 2023). Additionally, the National Energy Foundation's Interactive Electric Vehicle Education Experience is an educational program designed to educate students using a STEM-based curriculum about the benefits of EVs. This includes interactive experiences, competitions and digital materials to engage students and introduce them to vehicle electrification (National Energy Foundation, 2021). Southern California Edison (SCE) launched pilot programs such as Charge Ready Schools and Charge Ready Parks that contribute to the education and infrastructure needed to support EV adoption in the community (Southern California Edison, 2024).

These programs contribute to a more informed society by overcoming barriers to EV adoption, such as public concerns, cost concerns, and improving infrastructure availability. By providing clear, accessible information and dispelling myths, this initiative helps potential buyers see the practical benefits of EVs. Focus on education programs, especially for the younger generation, ensures that future drivers are aware of the environmental and economic benefits of electric vehicles. A strategic combination of public education campaigns, incentives, and infrastructure development programs has made EVs more attractive to consumers. As awareness grows and technology advances, the rate of adoption of EVs in California continues to increase, resulting in significant reductions in transportation-related emissions and bringing the state closer to its environmental goals.

Educating the public on the benefits of EVs can lead to higher adoption rates, reducing fossil fuel consumption and enhancing energy security. Along with that, awareness campaigns can be tailored to reach underserved communities, ensuring they have the knowledge to participate in the energy transition ensuring energy equity.

3.3.2 Sample Metrics for Policy Implementation Indicator

Using all the metrics created for each category that comes under the policy implementation indicator, the following is a sample that will make the assessment of any jurisdiction for this indicator very convenient. See Table 3.

Table 3 Metrics developed for each category of Policy Implementation Indicator

Factor	Metric	Target/Benchmark	Current Status
Legislative Support and Subsidies	EV-related legislations passed	Compatible laws to improve EV adoption	Examine the laws passed
	Financial incentives available	$X million allocated annually	$Y million allocated
	Budget allocation for EV initiatives	% increase year-over-year	Current budget allocation
Emissions Regulations	Stringency of emissions standards	Alignment with federal goals	Current standards stringency
	Compliance rates with emissions targets	% compliance	Current compliance rate
	Penalties and enforcement actions	Strict penalties	Actions taken this year
Energy Policies	Renewable energy targets	% of total energy	Current Percentage
	Progress towards renewable energy goals	% increase year-over-year	Current progress
	Incentives for renewable energy	$X million allocated annually	$Y million allocated
Education and Awareness programs	Public awareness campaigns	Regular campaign conduction	Campaigns this year
	EV-related educational initiatives in schools	Maximum involvement of schools	Current involvement
	Public engagement events	Events to be held regularly	Events held this year

By implementing these metrics, a jurisdiction can have assistance in systematically evaluating its progress in policy implementation for EV transition. This framework provides a clear, quantifiable way to assess and improve efforts, ensuring a comprehensive and equitable transition to electric vehicles.

3.3.3 Energy Infrastructure Development

Infrastructure development is a critical indicator for assessing a jurisdiction's progress in EV adoption for several reasons, which span from providing the necessary charging network to ensuring the integration of EVs into the broader energy system. To develop metrics for the "Infrastructure Development" indicator, we need to consider factors such as charging infrastructure availability, electric grid capacity, and reliability. Indicators like electric grid capacity and reliability, and the strategic placement of charging stations, are essential for restructuring the energy system to handle new demands from EVs. Ensuring that this restructuring considers equitable distribution across urban and rural areas is crucial for both energy security and equity. These metrics will help assess the progress and effectiveness of infrastructure development.

3.3.3.1 Charging Infrastructure Availability

This metric is categorized as the quantitative measure for energy infrastructure development. Progress of any jurisdiction for this indicator can be measured by the total number of charging stations per capita and their type (Level 1, Level 2, DC Fast Chargers) within the jurisdiction. The most direct link between infrastructure development and EV growth is the availability and density of charging systems. A network of reliable charging stations, including fast charging options, is essential to support the use of EVs,

especially for drivers who travel long distances and without charging at home. The availability of a wide and reliable charging infrastructure can significantly influence consumer confidence in purchasing an EV, as it eliminates various problems.

These metrics for this category should focus on the presence, public accessibility, and usage of EV charging stations, both public and residential, across different regions. The following are some of the metrics developed for the thesis that can be used to assess the charging infrastructure availability of a jurisdiction:

Number of public charging stations: Count the total number of public charging stations installed.

Number of fast-charging stations: Track the number of fast-charging (DC fast chargers) stations available.

California is at the forefront of supporting EV adoption through extensive infrastructure investments, regulations and incentives. California Assembly Bill (AB) 2127 directs the California Energy Commission to conduct a biennial assessment and report on how the state's EV charging infrastructure is meeting its 2030 and 2035 ZEV goals (CEC, 2023). This includes plans for light vehicles, trucks, off-road vehicles and equipment, and medium and heavy-duty vehicles. More than $10 billion in funding for zero-emission cars, trucks, buses and infrastructure as part of the historic $52 billion California Climate Agreement (CEC, 2023). The goal includes installing 250,000 chargers to accelerate the transition to ZEVs. Another $38 million project for EV charging in low-income and poor communities aims to close the rural charging gap and make EV charging more accessible to all Californians, especially in low-income and low-income communities. The payment covers 50% of the project cost or up to $100,000, depending on the capacity of the charger (CEC, 2023).

The Energized Commercial Vehicles (EnergIIZE) program targets infrastructure for medium and heavy-duty fuel cell and hydrogen fuel cell vehicles and offers a variety of financing options covering up to 75% of costs (California Energy Commission, 2022). In addition, the California Electric Vehicle Infrastructure Project (CALeVIP), which focuses on light vehicles, promotes the installation of Level 2 and DC fast chargers in conjunction with regional transportation agencies, with a special focus on low-income communities (CALeVIP, 2023).

Incentives of up to $19,500 are available for partners to purchase new electric vehicles, ease income levels and offer prepaid electric vehicle charging cards (CEC, 2023). Another $2.9 billion investment in zero-emission transportation infrastructure is part of the Clean Transportation Program, which aims to deploy 90,000 new EV chargers and support the transition to ZEVs, which will benefit priority populations (CEC, 2023). In addition, the $1 billion program focuses on charging infrastructure for low-income, tribal and underserved customers, with 70% of the funds directed to charging medium and heavy vehicles (CARB, 2022).

California currently has a total of 105,012 public and private EV chargers (CEC, 2024). Of these, 43,344 are public chargers, accounting for 41.28% of total chargers and they also include the destination chargers which are typically located at destinations where drivers are expected to spend a longer period of time, such as hotels, restaurants, shopping centers, and workplaces. 61,688 of them are private chargers making 58.72% of the total number. With a current population of 39.51 million, California has 911 public chargers per capita (CEC, 2024). The most populous city in California is Los Angeles with a population of 3.899 million and a total of 31,425 EV chargers including public and private chargers (CEC, 2024), giving Los Angeles 370 public chargers per capita. California's comprehensive approach to supporting EV adoption through infrastructure investment, regulatory measures and incentives is facilitating the

transition to a cleaner, more sustainable transportation system. Infrastructure investment and incentives have significantly increased EV adoption over time. In the second quarter of 2023, 25.4% of new vehicles sold in California were ZEVs, with a total of 125,939 ZEV sales in that quarter alone (CEC, 2024). This represents a significant market share of new car sales in the country, indicating a significant increase in EV adoption. California has taken an even bigger step by building more than 100,000 public chargers to support the growing number of EVs on the road (CEC, 2024). This extensive charging network is a key factor in encouraging consumers to switch to EVs.

To illustrate the impact of these investments and incentives on EV adoption in California, EV sales growth and charging system expansion over time are shown in Figure 5. This figure shows the number of EVs sold each year from 2015 to 2023, and the number of public chargers installed.

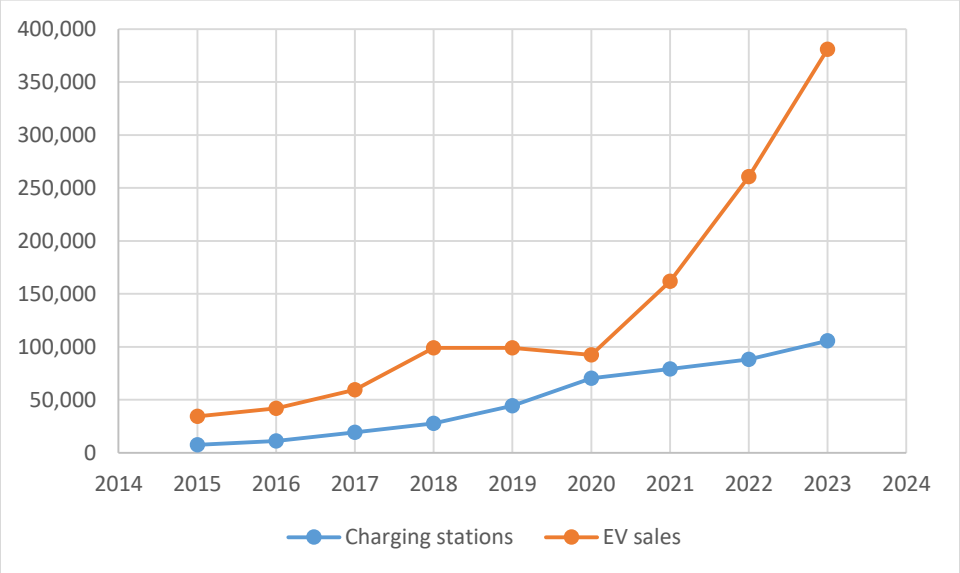

Figure 5 Growth in EV sales and Charging stations in California (2015-2023) (California Energy Commission, 2024)

While the data points are illustrative, they reflect a trend consistent with California's aggressive push for EV adoption and infrastructure development.

Key observations from the figure include:

- The data shows a sharp exponential increase in EV sales beginning around 2020. This surge is likely driven by several factors, including advancements in EV technology, increased consumer awareness, and more stringent environmental policies, particularly in states like California. The steep rise in EV sales after 2020 reflects a critical tipping point in the adoption of electric vehicles, indicating a shift from early adopters to a broader consumer base.
- The figure shows a divergence between the growth curves of EV sales and the number of charging stations. While both metrics are increasing, EV sales have surged at a much faster rate, particularly from 2020 onwards, whereas the growth in charging stations has been more gradual. This divergence highlights a potential gap in infrastructure development, where the increasing demand for EVs may soon outpace the available charging infrastructure if current trends continue.

- Despite the divergence, there is a steady increase in the number of charging stations over the years. This growth is essential for supporting the rising number of EVs on the road.

This trend underscores the effectiveness of California's approach, combining regulatory measures, financial incentives, and infrastructure investments to promote EV adoption. The expansion of the charging network, alongside increasing EV sales, demonstrates the state's progress toward its environmental goals and its transition toward sustainability.

A widespread charging network reduces range anxiety and supports the reliable use of EVs, contributing to energy security. However, to take the energy equity on board, it needs to be ensured that charging infrastructure is available in all areas, including rural and underserved regions, to promote equitable access to EVs.

3.3.3.2 Energy Grid Capacity

This sub-indicator is categorized as the quantitative measure for energy infrastructure development. Progress of any jurisdiction for this indicator can be measured by the jurisdiction's grid capacity to handle increased demand from EVs, potentially through metrics like peak load handling and investment in grid upgrades. As the number of EVs increases, so does the amount of electricity needed. It is important to ensure that the power grid can handle this increased load without compromising reliability. Infrastructure development in this area could include grid self-renewal and the integration of renewable energy sources, which could help reduce the carbon footprint of EVs.

Metrics in this category should evaluate the readiness and capacity of the electric grid to support the increased load from EVs, including investments in infrastructure and the integration of renewable energy. Following are some of the metrics developed for the thesis that can be used to assess electric grid capacity of a jurisdiction:

Grid capacity for EV load: Measure the percentage of the electric grid upgraded to handle the additional load from EVs.

Investment in grid infrastructure: Quantify the annual investment in upgrading grid infrastructure to support EVs.

Integration of renewable energy sources: Assess the proportion of the grid's energy mix that comes from renewable sources.

Load management programs: Track the implementation and participation rates in demand response and other load management programs.

In the new state regulations, 35% of new car models sold in California by 2026 should be EVs and it must increase to 100% by 2035 (CEC, 2024). This means that the state must triple the power generation capacity to operate vehicles and electrify other sectors of the economy and deploy new solar and wind power at about five times the rate of the last decade. With 15 times as many electric cars expected on California roads by 2035, consumption will increase rapidly. But the California Energy Commission says peak-hour use will remain a small fraction of all power, from 1% in 2022 to 5% in 2030 and 10% in 2035 (Lopez, 2023). California has undertaken significant measures to enhance its energy grid's capacity and reliability to support EV adoption. These initiatives aim at ensuring the grid can accommodate the increasing load from EVs without compromising reliability, while also integrating renewable energy sources to facilitate a cleaner energy transition. Governor Gavin Newsom announced California's Clean Energy Transition Plan, which aims for 100% clean electricity by 2045 (CAgov, 2022). This plan

emphasizes the acceleration of solar, wind, battery storage, and other clean energy projects to meet the state's clean energy goals. It also highlights technology's role in modernizing the electricity grid, including the use of zero-emission car batteries to supply power back to the grid, enhancing efficiency, reliability, and affordability. The California Public Utilities Commission (CPUC) has initiated efforts to modernize the electric grid to handle a high number of distributed energy resources, including EV charging infrastructure (CPUC, 2023). This initiative is designed to prepare the grid for a future with extensive distributed energy resources, focusing on enhancing grid reliability, integrating renewable generation, and promoting equity.

The country's portfolio of clean electricity and battery storage capacity has also seen significant growth. In 2021, more than 37% of California's electricity comes from sources that met the Renewables Portfolio Standard, and nearly 59% of retail electricity comes from non-residual fuel sources (CEC, 2022). Battery storage capacity has increased dramatically, from 250 megawatts to 5,000 megawatts in 2019, supporting the transition of millions of homes to electricity from renewable sources (CEC, 2022). These steps have a major impact on EV adoption in California. By ensuring access to reliable and clean electricity and expanding charging infrastructure, California is making EVs more affordable and attractive to a large portion of the population. A combination of investments focused on clean energy generation, grid modernization, and charging infrastructure and technology paves the way for a sustainable EV ecosystem and promises to drive long-term growth in EV adoption in the state.

With the increasing adoption of EVs, the electricity demand is also increasing, especially during peak charging times. To maintain energy security, the grid must have sufficient capacity to accommodate this additional load without risking outages or requiring the use of less reliable, often fossil-fuel-based, backup generators. An adequate grid capacity ensures that there is a continuous supply of power even during high-demand periods, such as extreme weather conditions when heating or cooling demands are high alongside EV charging needs. Increasing grid capacity may also involve integrating renewable energy sources like solar or wind, which can provide sustainable power to meet growing demands and enhance energy security by reducing dependency on imported fuels. However, to cater energy equity, it needs to be ensured that grid capacity is enhanced and distributed equitably across all regions is crucial to prevent disparities. Urban areas might naturally attract more infrastructure investment, but rural and underserved areas also need sufficient grid capacity to support EV adoption. If certain regions have inadequate grid capacity, they may face more frequent power disruptions or higher costs for energy, leading to inequality in access to the benefits of electrification. So, to reach an ideal state of energy security-equity nexus, these factors need to be considered.

3.3.4 Sample Metrics for Infrastructure Development Indicator

Using all the metrics created for each category that comes under the infrastructure development indicator, following is a sample that will make the assessment of any jurisdiction for this indicator very convenient. See Table 4.

Table 4 Sample Metrics for each category of Infrastructure Development Indicator

Factor	Metric	Target/Benchmark	Current Status
Charging Infrastructure Availability	Number of public charging stations	Increase the number of charging stations to facilitate the user	Number of stations installed
	Number of fast-charging stations	Maximize the number of DCFC fast charging	Current number

		stations to meet user demand	
Electric Grid Capacity and Reliability	Grid capacity for EV load	Upgradations in grid infrastructure to cater EV load	Current initiatives
	Investment in grid infrastructure	$X million annually	Current investment
	Integration of renewable energy sources	% of grid energy from renewables	Current integration rate
	Load management programs	% participation rate	Current participation

The implementation of these metrics in Nova Scotia will allow for a comprehensive evaluation of the progress made in infrastructure development to facilitate the transition to electric vehicles (EVs). This framework offers a clear, quantifiable method to meticulously assess ongoing efforts, thereby ensuring the establishment of a robust and dependable infrastructure designed to support the widespread adoption of electric vehicles.

To ensure energy security, reliability is critical for maintaining the continuous operation of the energy system, particularly as EVs become more prevalent. Frequent or prolonged outages could undermine confidence in electric mobility and hinder the transition to a cleaner energy system. A reliable grid is also essential for integrating renewable energy sources, which can be variable. Technologies like energy storage and smart grids can help manage this variability, ensuring that the grid remains stable even when renewable generation fluctuates. However, reliability should be ensured across all regions, including vulnerable and underserved communities. If reliability is compromised in certain areas, these communities might face more frequent disruptions, leading to higher costs and reduced access to electricity. Investing in grid reliability also means ensuring that all regions have access to the latest technologies, such as smart grids and energy storage, which can enhance the stability and reliability of electricity supply, thereby promoting energy equity. In this way, a good balance between energy security and equity can be maintained.

3.3.5 Market Penetration

The level of market penetration directly reflects the adoption of EVs in a jurisdiction. The high penetration rate reflects the successful transition from internal combustion engine vehicles to electric vehicles, demonstrating consumer acceptance and the effectiveness of policies aimed at promoting EVs. Progress of any jurisdiction for this indicator can be measured by tracking the number of EVs sold annually, comparing it to total vehicle sales to gauge EV market share.

To develop metrics for the "Market Penetration" indicator, we need to consider factors such as EV sales, the number of EV chargers, and overall market adoption rates. Tracking EV sales and market share reflects how effectively the market is replacing fossil-fuel vehicles with EVs. Ensuring that this replacement is equitable across different socioeconomic groups is important for energy equity. These metrics will help assess the progress and effectiveness of market penetration efforts.

3.3.5.1 EV Sales

The metrics for this category should focus on tracking the volume and growth of EV sales, including their share of new vehicle sales and comparisons with national trends. Following are some of the metrics developed for the thesis that can be used to assess the market penetration of EVs in a jurisdiction:

Percentage of new vehicle sales that are EVs: Measure the proportion of new vehicle sales that are electric.

Year-over-year growth in EV sales: Assess the annual growth rate of EV sales.

Comparison with national EV sales: Compare the EV sales in Nova Scotia to the national average or other provinces.

3.3.5.2 Number of EV Chargers

Metrics in this category should evaluate the availability and distribution of EV charging infrastructure, essential for supporting market penetration. Following are some of the metrics developed for the thesis that can be used to assess the progress of the number of EV chargers in a jurisdiction over time:

Total number of EV chargers installed: Count the total number of EV chargers installed.

3.3.5.3 Overall Market Adoption Rates

The metrics for this category should assess the broader market adoption of EVs, including their share in the total vehicle fleet, consumer interest, model availability, and the effectiveness of incentives. Following are some of the metrics developed for the thesis that can be used to assess the overall market adoption rates of EVs in a jurisdiction:

Market share of EVs in the total vehicle fleet: Measure the percentage of EVs in the overall vehicle fleet.

Consumer awareness and acceptance rates: Survey the percentage of consumers aware of and interested in purchasing EVs.

Availability of EV models: Track the number of different EV models available for purchase.

California has made significant progress in increasing EV adoption and market penetration, using an integrated approach that includes state funding and incentives, expanding charging infrastructure, and focusing on equity to ensure that all communities benefit from the transition to EVs. State funding and incentives have played an important role, and California offers a variety of benefits, incentive programs, and tax credits to individuals and companies. These incentives include reducing the financial burden associated with switching to EVs and incentives to purchase vehicles and install charging stations (CEC, 2023). For example, buyers of plug-in hybrid cars can typically get discounts of $1,000 to $3,500, with even higher incentives for buyers of fuel-cell EVs. The availability of charging stations has become critical, increasing the number of public charging stations from about 80,000 to 250,000 by 2025 (CEC, 2024). California has dedicated funding primarily for Level 2 charging stations, which are suitable for commercial settings and home charging, offering a full charge in 4-10 hours depending on the car and charger model (CAgov, 2022).

Moreover, the California Public Utilities Commission (CPUC) has adopted a $1 billion transportation electrification program focusing on charging infrastructure for medium and heavy-duty vehicles, light-duty charging at multi-unit dwellings, and offering higher rebates for projects in underserved, disadvantaged, and tribal communities (CPUC, 2023). This initiative is part of a broader effort to meet the

state's climate goals and ensure equitable access to charging infrastructure. The California Energy Commission (CEC) has also launched a $38 million project under the California Electric Vehicle Infrastructure Project (CALeVIP) to deploy EV fast chargers in low-income and disadvantaged communities across 28 counties (CALeVIP, 2023). This initiative aims to address the rural charging gap and ensure that every Californian has adequate access to public EV charging.

EV adoption has seen significant growth in California, with electric vehicles and charging stations leading in the United States since 2016 (CEC, 2023). By the end of 2022, California will be home to 37 percent of registered EVs and 27 percent of EV charging locations in the United States (CEC, 2024). The number of EVs registered in California will more than quadruple between 2016 and 2022, from 247,400 to 1.1 million, shown in Figure 6. California's car market share this year is 21%, the highest in the United States. This represents 40% of all zero-emission vehicles sold in the United States. California is responsible for nearly half of the US total. In the US, EVs made up 5.6% of sales in 2022. By the end of Q1 2023, EV sales in California totaled 1,523,966, with the rest mostly a mix of PHEVs and fuel cell vehicles. A total of 124,053 EVs were sold in Q1, so the 1.5 million sales milestone was set earlier this year (CEC, 2024). The move adds to a total of $2 billion in zero-emissions incentives that the state has distributed over the years. This doesn't compare to the roughly $649 billion in fossil fuel subsidies in the United States (CEC, 2023).

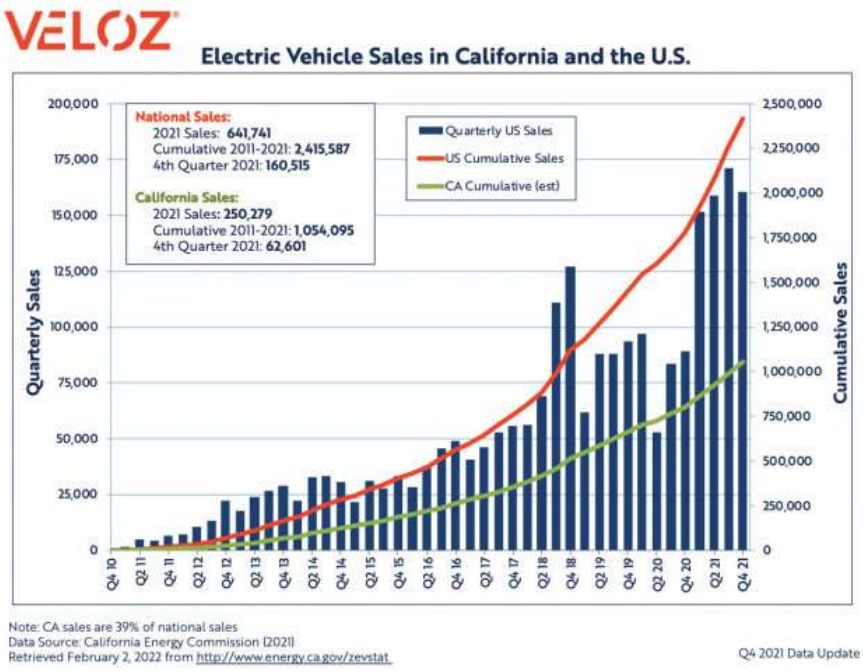

Figure 6 EV Sales in California and the US (California Energy Commission, 2024)

When it comes to affordability, California's used EV market offers plenty of affordable options. There are between 20 and 50 used EV models available, with an additional 20 models priced under $20,000 which shows that there is a significant portion of the EV market available to buyers on a limited budget (CEC, 2024). It's also worth noting that California is the top market for electric vehicles with the most EV inventory. Popular EV models in California include the Tesla Model Y, the best-selling vehicle in California, ahead of traditional leaders like the Toyota Camry and RAV4. The Chevy Bolt EV and EUV

are also big contributors, accounting for eight percent of battery-electric vehicle sales and showing market demand for small, affordable EVs (CEC, 2024).

As more Electric Vehicles (EVs) enter the market and achieve higher sales, the overall reliance on imported oil and fossil fuels decreases. This shift supports domestic energy production by increasing the demand for electricity, which can be generated from a variety of sources, including renewable energy like wind, solar, and hydro. By reducing the dependence on foreign oil, a country enhances its energy security, making its energy supply more resilient to geopolitical tensions, price volatility, and supply disruptions that are common in global oil markets. Additionally, a diversified energy mix, supported by the growth of the EV market, can lead to greater energy independence, where the country relies more on its own resources to meet its energy needs. However, monitoring the sales and market share of EVs is essential for identifying disparities in EV adoption across different demographics, regions, and income levels. If certain groups or areas are underrepresented in the EV market, it could indicate barriers such as higher costs, lack of infrastructure, or insufficient awareness. By analyzing these trends, policymakers can implement targeted interventions to promote inclusivity. For example, they might introduce subsidies or incentives aimed at low-income households or invest in charging infrastructure in rural or underserved areas to ensure that everyone can benefit from the transition to electric mobility. Furthermore, equitable EV adoption can help bridge the gap between different socioeconomic groups, ensuring that the environmental and economic benefits of EVs, such as reduced transportation costs and lower emissions, are shared more broadly across society. This can help to achieve an ideal state of energy security-equity nexus.

In summary, market penetration is a multidimensional indicator that reflects consumer behavior, infrastructure development, environmental impact, and overall policy effectiveness and economic health related to EV adoption in a jurisdiction.

3.3.5.4 Sample Metrics for Market Penetration Indicator

Using all the metrics created for each category that comes under the market penetration indicator, the following is a sample that will make the assessment of any jurisdiction for this indicator very convenient. See Table 5.

Table 5 Sample Metrics for each category of Market Penetration Indicator

Factor	Metric	Target/Benchmark	Current Status
EV Sales	Year-over-year growth in EV sales	X% growth	Current growth rate
	Comparison with national EV sales	% difference from the national average	Current comparison
Number of EV Chargers	Total number of EV chargers installed	X stations per 10,000 residents	Current number
Overall Market Adoption Rates	Market share of EVs in the total vehicle fleet	X% of total fleet	Current market share
	Consumer awareness and acceptance rates	X% of surveyed consumers	Current awareness rate
	Availability of EV models	Number of available models	Current availability

By implementing these metrics, Nova Scotia can have assistance in systematically evaluating its progress in market penetration for EV transition. This structured approach offers a precise and measurable method for assessing and enhancing initiatives, guaranteeing a strong and expanding market for electric vehicles.

3.3.6 Equity Considerations

The reason why equity consideration is a crucial indicator for assessing a jurisdiction's progress towards EV adoption is that it ensures that the benefits of EV technology are accessible to all segments of the population, regardless of income, geography, or other socioeconomic factors. To develop metrics for the "Equity Consideration" indicator, we need to consider factors such as economic inclusivity, infrastructure distribution, and workforce development. Economic inclusivity and workforce development are critical for ensuring that the restructuring of the energy system benefits all segments of society. This involves creating jobs and opportunities in the new energy economy that are accessible to everyone, including historically marginalized groups. These metrics will help assess the progress and effectiveness of ensuring an equitable EV transition.

3.3.6.1 Economic Inclusivity

This metric is categorized as the quantitative measure for equity consideration. The progress of any jurisdiction for this indicator can be measured by measuring indicators such as the affordability of EVs within the jurisdiction, available financing options, and subsidies for lower-income households. Equity considerations address the economic barriers to EV ownership. By implementing policies that make EVs more affordable through incentives, rebates, and financing options targeted at low- and moderate-income households, jurisdictions can promote economic inclusivity.

The metrics for this category should focus on the financial accessibility of EVs for different income groups, ensuring that subsidies and incentives reach those who need them most, and that charging costs remain affordable. Following are some of the metrics developed for the thesis that can be used to assess the economic inclusivity for different income groups in a jurisdiction:

Affordability of EVs: Measure the average cost of EVs compared to the average income levels.

Subsidy distribution: Assess the proportion of subsidies and incentives utilized by low- and middle-income households.

California has taken significant steps to address equity issues to support EV adoption, focusing on economic barriers to purchasing EVs, such as cost and availability of charging infrastructure. These steps are designed to make electric cars more accessible and affordable, especially for low- and middle-income households, and promote economic inclusion. One notable initiative is a $38 million California Energy Commission (CEC)-directed incentive project to fund public EV charging stations in low-income and disadvantaged communities in 28 California counties (CEC, 2023). The initiative, part of the California Electric Vehicle Infrastructure Project (CALeVIP), aims to deploy EV fast chargers in communities most affected by air pollution, paying 50 percent of the total cost of the project, or up to $100,000 based on the capacity of the charger (CALeVIP, 2023).

Furthermore, the state is doubling its EV charging infrastructure with a $3 billion investment, aiming to increase the number of publicly available chargers from 80,000 to 170,000 by 2025 (CEC, 2024). This effort targets low-income and historically disadvantaged communities, supporting the deployment of zero-emission trucks, school buses, and transit buses to deliver clean air benefits and good-paying jobs.

In terms of direct incentives for EV purchasers, the Clean Vehicle Rebate Project (CVRP) has increased incentives by $3,000 for low-to-moderate income-qualifying applicants, offering total incentives of $7,500 for battery EVs (BEVs) and $6,500 for Plug-In Hybrid EVs (PHEVs) (CARB, 2023). The Clean Cars 4 All program, expanding statewide, offers up to $10,000 for new or used BEVs and up to $9,500 for PHEVs for low-income consumers in disadvantaged communities (California Air Resource Board, 2023). Additionally, the state has revamped its financing program, providing price buy-down grants that

have increased by $2,500 to $7,500 and $7,000 for new or used BEVs and PHEVs, respectively, for lower-income residents (CEC, 2023).

This measure is crucial for addressing the challenges of affordability and public accessibility of EVs and charging infrastructure for all Californians, especially those from low-income and disadvantaged communities. The focus on economic equity in EV adoption and the substantial investments in charging infrastructure demonstrate California's commitment to environmental justice and sustainable transportation. In the long run, these initiatives are expected to significantly boost EV adoption in California by making EVs more affordable and accessible to a broader range of consumers, thus helping to reduce greenhouse gas emissions and improve air quality across the state.

Ensuring that electric vehicles (EVs) are affordable and accessible to a wide range of economic groups is crucial for fostering broader adoption across society. When EVs are priced within reach of middle- and low-income individuals, more people can transition from traditional internal combustion engine vehicles to EVs. This widespread adoption reduces the overall demand for fossil fuels, which in turn diminishes reliance on imported oil, a key factor in enhancing national energy security. A broader base of EV users also leads to greater diversification of energy sources. By increasing the number of EVs on the road, there is a corresponding increase in the electricity demand, which can be met by a mix of renewable energy sources. This shift away from fossil fuels towards more stable, domestically-produced energy sources helps secure a nation's energy future. Economic inclusivity in the EV market is fundamental to reducing disparities in access to clean transportation. Programs and policies that make EVs more affordable, such as subsidies, tax incentives, and low-interest loans for low-income individuals, directly contribute to reducing these disparities. By lowering the financial barriers to EV ownership, these initiatives ensure that the benefits of clean transportation, such as lower fuel costs, reduced maintenance expenses, and decreased emissions. They are accessible to a broader segment of the population, including those who have historically been marginalized or underserved ensuring energy equity.

3.3.6.2 Infrastructure Distribution

Equitable distribution of EV charging infrastructure is critical to ensure that charging stations are accessible in all neighborhoods, including rural areas and urban communities with limited parking, as it supports widespread EV adoption and prevents "charging deserts" in underserved areas.

Metrics in this category should evaluate the equitable distribution and public accessibility of EV charging infrastructure, ensuring that all communities, including underserved areas, have adequate access. Following are some of the metrics developed for the thesis that can be used to assess the infrastructure distribution for EVs in a jurisdiction:

Equitable distribution of charging infrastructure: Measure the availability of charging stations in underserved areas (rural, low-income urban neighborhoods).

California has taken significant steps to address the equitable distribution of EV charging infrastructure among rural and urban areas, as well as within underserved communities. These efforts aim to support EV adoption by ensuring that charging stations are accessible to all Californians. One notable initiative involves the mandate by CALGreen, which has required access to power for EV charging in all new California single-family homes since 2015 (IN Balance Green Consulting, 2023). However, the state has lagged in extending these mandates to multifamily housing. Only a small percentage of multifamily housing parking spaces were required to have charging access as of the beginning of the 2022 code cycle, though efforts are underway to increase this to 20%. California's approach to EV infrastructure also emphasizes the importance of consumer education and community buy-in, acknowledging the role of

local governments in developing comprehensive strategies that consider the specific needs and contexts of different communities (California Air Resource Board, 2023).

CEC launched the California Electric Vehicle Infrastructure Project (CALeVIP), a $38 million investment initiative to fund public EV charging stations in low-income and vulnerable communities in 28 counties (CALeVIP, 2023). This effort aims to bridge the rural charging gap and ensure equal access to public EV charging infrastructure. Berkeley Law's EV Equity initiative highlights the importance of developing a locally organized, community-driven approach to building EVs. This includes identifying policy, legal, financial and infrastructure barriers to equitable EV deployment (Berkeley Law, 2022).

The total number of EV chargers (both public and private) in California is 105,012 according to the latest update by the California Energy Commission. And the population of California is 38,940,231 according to the 2023 census (CEC, 2024). The top 5 most populated counties of California are Los Angeles, San Diego, Orange, Riverside, and San Bernardino respectively (Cubit, 2023).Table 6 shows counties with their respective population, the total number of EV chargers, and the number of DC fast chargers and Level 2 chargers.

Table 6 California's most populated counties with their respective number of EV chargers (California Energy Commission, 2024)

Name of County	Population	DC Fast Chargers	Level 2 Chargers	Total Chargers
Los Angeles	9,539,730	2,286	29,139	31,425
San Diego	3,278,716	753	7,813	8,566
Orange	3,131,542	929	5,841	6,770
Riverside	2,515,350	1,255	579	1,834
San Bernardino	2,195,204	1,315	630	1,945

The collective population of these counties is 20,660,542 which is 53.05% of the total population of California. These states in total have 50,540 EV chargers which is 48.12% of the total EV chargers in California (CEC, 2024). This shows how well the EV charging infrastructure is dispersed in the state. EV chargers in all the rural areas are dispersed according to their population which is a role model for all the other jurisdictions that are looking to cater to the issue of equitable infrastructure distribution.

These initiatives are crucial for supporting widespread EV adoption in California. By increasing the public accessibility of EV charging infrastructure, especially in underserved and rural areas, California aims to reduce the disparities in EV adoption rates and ensure that the benefits of electric transportation are shared equitably across the state (CEC, 2023). The focus on equity and public accessibility, along with substantial investment in charging infrastructure, is expected to encourage more Californians to consider EVs as a viable transportation option, thereby contributing to the state's environmental and air quality goals.

The distribution of EV charging infrastructure must be strategically balanced to avoid overloading certain areas of the electric grid, which could lead to localized stress or even outages. By ensuring that charging stations are evenly spread across both urban and rural areas, the energy demand from EVs can be more evenly distributed, thereby preventing grid congestion in high-demand zones. Balanced infrastructure distribution enhances the overall resilience of the energy system. In the event of a localized issue, such as a power outage or maintenance work, a well-distributed network ensures that other areas remain operational, minimizing disruptions to the EV charging network and maintaining energy security. This distribution is crucial for creating a robust energy system that can withstand varying levels of demand

across different regions. However, equitable distribution of EV infrastructure is also essential to prevent disparities in energy access between urban and rural areas. If charging stations are concentrated only in urban centers, rural communities may face significant barriers to adopting EVs, including long travel distances to the nearest charging point. This creates an unequal energy landscape where only certain populations can fully benefit from the transition to EVs. By ensuring that infrastructure is accessible in rural and underserved areas, the energy transition becomes more inclusive. Equitable infrastructure distribution allows all communities to participate in the benefits of cleaner transportation, such as reduced air pollution and lower operating costs. It also prevents the creation of "energy deserts," where certain populations are left behind in the shift towards sustainable energy solutions. Furthermore, equitable distribution promotes social cohesion and trust in government policies, as communities across the socio-economic spectrum can see tangible benefits from the energy transition. It addresses potential disparities in energy access, thereby contributing to a more just and fair transition to sustainable energy. All these factors need to be considered to maintain a good balance between energy security and energy equity.

3.3.6.3 Workforce Development

This sub-indicator is categorized as the qualitative measure for equity consideration. Progress of any jurisdiction for this indicator can be measured by assessing initiatives aimed at training and employing a workforce in the EV industry, focusing on inclusivity and the provision of opportunities for underrepresented groups. The transition to EVs creates job opportunities in manufacturing, infrastructure development and maintenance. Consumer-oriented policies can ensure that the economic benefits of the EV industry are shared widely and support workforce development programs that train and recruit disadvantaged people.

The metrics in this category should assess the creation of training programs and job opportunities in the EV sector, with a focus on inclusivity and support for local businesses. The following are some of the metrics developed for the thesis that can be used to assess the workforce development in a jurisdiction:
Training programs for EV-related jobs: Count the number and reach of training and certification programs for EV maintenance, manufacturing, and infrastructure development.

Diversity in the EV workforce: Assess the demographic diversity (gender, race, socioeconomic background) of the workforce in the EV sector.

California has made significant strides in workforce development to support the EV industry, with a focus on job creation in manufacturing, infrastructure development, services and investment policies. This effort is an integral part of the country's leadership in supporting the adoption of ZEV and supporting infrastructure aimed at reducing greenhouse gas emissions and developing clean transportation technologies.

The California Energy Commission invests in manufacturing and workforce training and development through the Clean Transportation Program (formerly known as the Alternative and Renewable Fuels and Transportation Technologies Program) (CEC, 2022). This investment is aimed at expanding existing programs and developing new initiatives to support those working in the country's ZEV and ZEV infrastructure sectors. Key community partners in this effort include the California Community College Advanced Transportation and Logistics Program, the California Community College Chancellor's Office, the Department of Employment, and the Employment Panel (California Energy Commission, 2023). These partnerships and investments are designed to support the state's transition to clean transportation, provide clean transportation job opportunities, and meet the state's greenhouse gas reduction goals.

In addition, the Governor's Office of Business and Economic Development (GO-Biz) plays a key role in creating opportunities to accelerate the growth of the ZEV market (GO-Biz, 2024). It focuses on incentives, regulations, workforce development and stakeholder engagement to deliver the technology and scale needed for a prosperous, clean and climate-friendly future. California's approach includes a comprehensive strategy to develop the ZEV market, and growing efforts to collectively advance and deliver ZEV benefits to all Californians. This strategy involves collaborating with multiple agencies and partners to make California's vision of 100% ZEV adoption a reality (CARB, 2022).

The California Workforce Development Board (CWDB) contributes to these initiatives by addressing labor market disparities and increasing employment opportunities for low-income populations, including those formerly incarcerated and the justice system (Zabin, 2020). Programs such as the Aviation Research Course, in partnership with West Los Angeles College and supported by SEIU-USWW, facilitate programs designed to increase employment and create job opportunities (West LA College, 2024). This initiative focuses on providing training, retraining, professional development and support services to targeted populations, including members of the non-traditional workforce.

This collaborative effort by various California government agencies and partners aims not only to develop the skilled workforce needed for the EV industry to grow but also to ensure that the economic benefits of the EV industry are shared widely, including with disadvantaged people (CEC, 2023). California is paving the way for increased EV adoption by creating a supportive ecosystem for zero-emission vehicles, including developing a strong workforce and creating supportive policies and incentives. This dynamic approach is designed to not only address current needs but to have a long-term positive impact on EV adoption in the state.

As the adoption of Electric Vehicles (EVs) grows, maintaining and expanding the necessary infrastructure, such as charging stations and grid integration, becomes critical. A skilled workforce is essential in this regard. Workers trained in EV technology, charging infrastructure installation, grid management, and maintenance ensure that the EV ecosystem operates efficiently and reliably. A robust workforce supports the development of resilient infrastructure, which in turn contributes to the overall energy security of a region. When the infrastructure is managed by well-trained professionals, it minimizes the risk of system failures or outages, ensuring a continuous and secure supply of energy for EV users. Additionally, as new technologies emerge and the EV market evolves, a workforce that is adaptable and skilled in the latest advancements can help integrate new solutions into the energy grid. This adaptability is crucial for sustaining long-term energy security in a rapidly changing energy landscape. Taking energy equity into consideration, workforce development initiatives can play a significant role in promoting social equity by providing marginalized or underserved communities with access to training and job opportunities in the green economy. These programs can focus on equipping individuals with the skills needed to participate in the growing EV industry, whether in manufacturing, infrastructure development, maintenance, or customer service. By opening pathways to employment in the EV sector, these programs can help reduce economic disparities and ensure that the benefits of the transition to cleaner energy are shared more broadly across society. For example, training programs in low-income or rural areas can empower residents to take part in the new economy, leading to economic upliftment and greater community resilience. Moreover, integrating workforce development with equity-focused policies ensures that the jobs created in the EV sector are accessible to those who need them most, fostering an inclusive transition to a sustainable energy future. This approach not only promotes social equity but also strengthens the overall societal support for energy transitions, ensuring a more balanced and just approach to energy security. In this way, a good balance between both energy security and energy equity can be maintained.

3.3.7 Sample Metrics for Equity Consideration Indicator

To ensure a fair shift to electric vehicles, Nova Scotia can use these metrics to measure its progress consistently. This approach offers a specific and measurable method to evaluate and enhance initiatives, guaranteeing that the advantages of EV adoption are equitably distributed among all communities. See Table 7.

Table 7 Sample Metrics for each category of Equity Consideration Indicator

Factor	Metric	Target/Benchmark	Current status
Economic Inclusivity	Affordability of EVs	Initiatives for low-income households	Current affordability
	Subsidy distribution	% of subsidies to low/middle-income households	Current distribution
Infrastructure Distribution	Equitable distribution of charging infrastructure	% of stations in underserved areas	Current distribution
Workforce Development	Training programs for EV-related jobs	Number of programs and participants	Current number of programs
	Diversity in the EV workforce	Demographic breakdown	Current workforce diversity

3.4 Implementing the Measurement Approach

To effectively use this methodology, a jurisdiction should:

Establish Baselines: For each quantitative metric, establish current figures to serve as a baseline for future comparison. Without clear baselines, it's challenging to measure the impact of policies or initiatives.

Regular Monitoring: Implement systems for regularly collecting data on each of the metrics. This could involve leveraging existing government data, conducting surveys, and engaging with local businesses and communities. It ensures that progress is tracked effectively and allows for timely interventions if targets are not being met. This ongoing monitoring provides a dynamic view of the jurisdiction's EV landscape.

Stakeholder Engagement: Engage with stakeholders across sectors to obtain qualitative insights, particularly for metrics that are less directly measurable. This includes workshops, interviews, and public feedback mechanisms. They can offer perspectives on challenges, successes, and areas needing attention that might not be captured through data alone.

Data Analysis and Reporting: Analyze collected data to identify trends, progress, and areas requiring attention. Reporting should be transparent, accessible, and include actionable insights. Transparent reporting ensures that findings are accessible to policymakers, stakeholders, and the public, fostering accountability and informed decision-making.

Adaptation and Policy Feedback: Use the insights gained from the analysis to inform policy adjustments, infrastructure investments, and targeted initiatives to address gaps or accelerate progress. It is crucial for maintaining relevance and effectiveness. This feedback loop ensures that the jurisdiction can address evolving challenges and capitalize on opportunities to accelerate progress.

This innovative approach for assessing a jurisdiction's progress towards the transition to electric vehicles involves a blend of various metrics and factors. By capturing both tangible and intangible measures of success, as well as the nuances of policy and community engagement, this approach offers a more comprehensive and nuanced evaluation of the EV transition progress. This in-depth analysis can help jurisdictions identify areas where they are excelling and areas where they need to improve, ultimately leading to a more successful and efficient transition to electric vehicles.

3.5 Chapter Summary

All these indicators mentioned are very crucial to assess any jurisdiction’s progress in EV transition as they highlight every aspect which cannot essentially be overlooked by anyone who wants to judge how well are EVs adopted by the respective jurisdiction. California being the leading jurisdiction in the world for EV adoption justifies every indicator mentioned above and shows how important it is to be above par on every indicator for a smooth transition process from ICEVs to ZEVs. Due to the worldwide recognition of California for EV adoption, it can be used as an example to see how other jurisdictions are progressing in their transition to ZEV's journey.

4. CASE STUDY

The transition to Electric Vehicles (EVs) represents a pivotal element in the global shift towards sustainable transportation, reflecting an urgent need to address climate change and reduce reliance on fossil fuels. This case study focuses on Nova Scotia, a province at a critical juncture in its journey towards electrification of its transportation sector. By exploring the details of EV adoption within Nova Scotia, this study aims to provide a comprehensive understanding of the province's current position, its challenges, and the opportunities that lie ahead. This endeavor is crucial, considering the growing importance of electric vehicles in achieving energy security and equity within the context of environmental sustainability.

The methodology chapter introduced a set of indicators designed to assess the progress of EV adoption in any jurisdiction. These indicators include Policy Implementation, Infrastructure Development, Market Penetration, and Equity Consideration. Each plays a vital role in understanding the multifaceted approach required for a successful transition to EVs. Policy Implementation examines the governmental and legislative framework guiding EV adoption. Infrastructure Development assesses the availability and accessibility of EV charging stations and other necessary facilities. Market Penetration evaluates the uptake of electric vehicles among consumers, and Equity Consideration explores the fairness and inclusiveness of this transition across different demographics.

Nova Scotia's efforts and achievements in EV adoption will be scrutinized through these indicators, drawing direct comparisons with California—a frontrunner in EV adoption globally. Such a comparison is instrumental in highlighting Nova Scotia's relative standing and the specific areas where it lags. California's success story provides valuable lessons on effective strategies and best practices in promoting EV adoption. Through this comparative analysis, this study seeks not only to pinpoint the gaps and challenges faced by Nova Scotia but also to outline actionable recommendations and strategies for policymakers. The ultimate goal is to enhance Nova Scotia's performance across all indicators, thereby accelerating its transition to electric vehicles.

This case study will highlight the critical factors influencing EV adoption in Nova Scotia, offering a path forward through the adoption of proven strategies and tailored recommendations. By addressing the shortcomings and leveraging the lessons learned from California, Nova Scotia can forge a more sustainable, equitable, and prosperous future in the realm of electric transportation.

4.1 Nova Scotia’s EV Uptake

The uptake of EVs in Nova Scotia has been a path marked by incremental progress against the backdrop of broader national and international trends toward sustainability and the reduction of Greenhouse Gas Emissions (GHG). The province has recognized the critical role that the electrification of transportation plays in achieving environmental sustainability goals. However, while showing signs of positive momentum, Nova Scotia's transition to EVs also reflects a landscape of challenges and opportunities that are characteristic of regions striving to align local capabilities with global aspirations.

Nova Scotia's EV adoption rate has been gradually increasing, yet it remains modest compared to leading jurisdictions like California (DEC, 2020). The province has seen a rise in both the sale of electric vehicles and the deployment of EV charging infrastructure, however, the overall percentage of EVs on the road in Nova Scotia, compared to the total number of vehicles, indicates that there is significant room for growth in EV adoption (DEC, 2020).

The evolution of Nova Scotia's EV landscape can be traced back to the early initiatives focused on environmental sustainability and climate change mitigation. The current landscape for the adoption of EVs has been shaped by various factors. Compared to other Canadian provinces, the lack of a provincial ZEV mandate has put Nova Scotia behind the leading jurisdictions in terms of EV adoption. Provincial ZEV mandates have proven to have a clear impact on adoption, as demonstrated by Quebec, British Columbia, and Ontario (DEC, 2020).

However, the introduction of the federal government's "iZEV" purchase incentive program in 2019 has helped overcome some of the barriers associated with the higher up-front cost of EVs, and sales have increased in recent months (Transport Canada, 2024). Nevertheless, the overall offer in Nova Scotia is less generous than other provinces with combined provincial and federal incentives.

Fortunately, Nova Scotia has seen significant investment in public charging infrastructure, due to the initiatives led by Nova Scotia Power (NSPI) and some private organizations like Tesla, Irving Oil, and PetroCan with the support of the federal government through Natural Resources Canada's Electric Vehicle and Alternative Fuel Infrastructure Deployment Initiative (EVAFIDI) and Zero Emission Vehicle Infrastructure Program (ZEVIP). As of 2024, Nova Scotia has approximately 236 public EV charging stations. This network includes a mix of Level 2 and Level 3 DC-fast charging stations, strategically installed across the province with support from Nova Scotia Power, the federal government, and private organizations (NSP, 2023). These deployments provide EV drivers with access to significantly more charging infrastructure. However, ongoing expansions will be required, and there's uncertainty around future investments given that the Nova Scotia Utility and Review Board rejected NSPI's request to make rate-based investments in charging infrastructure (NRCan, 2022).

The Clean Foundation's "Next Ride" initiative has been successful in recent education and awareness efforts. With more than 89 events, over 1,200 test drives, and 5,000 engagements, the initiative has helped raise awareness about the benefits of EVs (CF, 2021). Additionally, the Clean Foundation has developed a web platform (EV Assist Nova Scotia) to provide information on EV basics, owning an EV, electric charging, and available infrastructure in Nova Scotia. Since its successful launch, the initiative has partnered with CAA Atlantic, allowing more people to test-drive EVs, including the Tesla Model 3. This partnership, supported by the Connect2 program, has made EV test drives more accessible, helping to increase public awareness and interest in EVs (CF, 2021). In addition, the Clean Foundation has been collaborating with municipalities, including Halifax, to host numerous EV test drive events throughout 2024. These events are part of Halifax's broader electric vehicle strategy, which aims to reduce transportation-related emissions and support the adoption of EVs by installing public charging infrastructure (HRM, 2024).

Despite these advancements, Nova Scotia's EV adoption faces several hurdles, including a need for more extensive and evenly distributed charging infrastructure, higher upfront costs of EVs compared to traditional vehicles, and a general lack of awareness or skepticism about EV capabilities among the broader public. The province's progress in EV adoption is also influenced by its unique geographical, economic, and social characteristics, which can pose additional challenges to the rapid adoption seen in more urbanized or wealthier regions like California.

4.2 Assessment of Policy Implementation in Nova Scotia

This analysis encompasses the scope and impact of legislative support for EVs, subsidies, emissions regulations, education and awareness programs. Together, these components offer a comprehensive view of the policy environment shaping EV adoption in the province.

Financial incentives, such as rebates for purchasing new or used electric vehicles, have been proved pivotal in the EV transition for jurisdictions notably British Columbia, Quebec and California (Dunsky, 2023). These incentives lower the cost barrier for individuals considering an EV, making electric vehicles more financially accessible. Nova Scotia offers a maximum $3,000 provincial rebate for both new BEVs and PHEVs. For used vehicle rebates, the province offers between $1,000 to $2,000. This rebate can also be stacked with the federal $5,000 rebate. Nova Scotians can save up to $8,000 on zero-emission vehicle purchases (EVA, 2023). But these rebates can be given under certain conditions. The base model for passenger vehicles must be below $55,000 MSRP. Higher priced trim levels for passenger vehicles are only rebate eligible up to $65,000 MSRP (light trucks have a limit of $60,000-$70,000) (EVA, 2023). The provincial rebate requirements in Nova Scotia align with the federal iZEV (Incentives for Zero-Emission Vehicles) program. Both programs set similar eligibility criteria for vehicle price limits, ensuring that the rebates are targeted towards more affordable electric vehicles. This alignment between provincial and federal rebate programs ensures that Nova Scotians can maximize their savings when purchasing a zero-emission vehicle, potentially receiving up to $8,000 in combined rebates. This coordinated approach not only makes EVs more accessible but also supports a more streamlined and cohesive national strategy for promoting EV adoption across Canada.

Nova Scotia has two programs available for the installation of EV charging stations. The first one is the EV Ready Approach program which is a pathway that provides two rebates to support the installation of EV charging stations within Multi-Unit Residential Buildings (MURBS). Producing an EV Ready Plan, and if approved, being eligible for 50% coverage to install chargers according to your approved plan (ENS, 2023). The second one is the Standalone EV Charger rebate for installing eligible charging stations at existing apartment and condo buildings with four or more residential units located in Nova Scotia. This pathway provides lower rebates compared to the EV Ready Approach, but it’s a simpler process for smaller projects or when installing your initial charging stations. Rebates of 50% of eligible costs, up to $2,500 per station (max $10,000 per building) are available for existing buildings (ENS, 2023).

There are initiatives aimed at encouraging the conversion of public and private vehicle fleets to electric. This includes subsidies or financial assistance for businesses and government departments to transition their fleets to EVs. The federal government has recently revealed its plan to invest over $37 million in bringing in 60 new battery-operated, electric buses to the Halifax Regional Municipality (HRM). This move is expected to significantly reduce GHG by 3,800 tonnes annually by 2030 (Transport Canada, 2022). The electric fleet will be the first of its kind in Atlantic Canada and will play a vital role in the region's efforts to reduce carbon emissions. The expansion of Halifax Transit's electric fleet will not only provide better transportation facilities to the public but will also help the government achieve its ambitious climate change goal of becoming carbon neutral by 2050 (Halifax Transit, 2023). This project will put the Halifax Transit system at the forefront of transit electrification in Atlantic Canada.

The funding will not only be used to purchase the electric buses but also to buy the necessary charging equipment and expand the Ragged Lake Transit Centre to accommodate the new fleet. The facility will undergo a deep energy retrofit, including solar panels, to achieve a net-zero standard (Transport Canada, 2024).

The total cost of the project is estimated to be $112 million, with contributions coming from three levels of government. The federal government is contributing $44.8 million, while Halifax Regional Municipality (HRM) is contributing $29.8 million. Construction on the facility is expected to begin in 2022 and be completed by 2023. The request for proposals for the electric buses will be issued later this summer, and all buses are expected to be delivered by 2024, with the first deliveries in 2023 (Transport Canada, 2024).

Though Canada's emissions regulations are largely dictated at the federal level, Nova Scotia has committed to adhering to stringent emissions standards. These regulations serve as an indirect driver for EV adoption, as they incentivize both manufacturers and consumers to pivot towards cleaner transportation options. Nova Scotia has set a remarkable target of reducing GHG by 53% below 2005 levels by 2030, which is one of the most ambitious climate goals in the country (DEC, 2020). The province has also committed to achieving net-zero emissions by 2050, which means balancing the amount of greenhouse gases produced with the amount removed from the atmosphere. To achieve these targets, Nova Scotia's Environmental Goals and Climate Change Reduction Act was passed in 2021, which outlines the province's comprehensive response to climate change (DEC, 2020). This includes closing all coal-fired power plants and ensuring that 80% of electricity comes from renewable sources by 2030.

To further elaborate on the plan, Nova Scotia released a detailed climate change plan that provides additional information on how the 2030 emissions target will be achieved, as well as set the course for 2050. (DEC, 2020). The Nova Scotia Output-Based Pricing System (NS OBPS) is a carbon pricing mechanism specifically designed for industrial facilities in Nova Scotia. The NS OBPS is a replacement for the federal carbon pricing mechanism, providing Nova Scotia with greater control over how carbon pricing is implemented in the province. The system is part of Nova Scotia's broader climate strategy, including initiatives like the Environmental Goals and Climate Change Reduction Act, to achieve significant emissions reductions by 2030 and beyond. Additionally, the province's cap-and-trade system, which is a market-based approach to lowering emissions ended in December 2023 and OBPS is under use now. These strict emission standards will tend to show a positive impact overall on EV adoption in the province.

4.2.1 Progress Criteria for Policy Implementation Indicator

To provide a more subjective assessment of Nova Scotia's progress, especially in comparison to California, we can look at each metric and determine what constitutes good or bad progress.

Legislative Support and subsidies: Good progress is marked by Nova Scotia’s proactive efforts to introduce and pass new legislation that directly supports the growth of the EV market. This would involve passing multiple laws each year that address not only the adoption of EVs but also the broader ecosystem, including infrastructure development and consumer protection. Nova Scotia would be showing good progress if these laws are in line with or more advanced than California's, where comprehensive legislation often leads the way in green technology. Financial incentives that significantly lower the cost barrier for consumers and businesses adopting EV technology also signal good progress. For example, Nova Scotia could mirror California's robust rebate programs and even expand them to cover more vehicle types, charging infrastructure, or public transportation initiatives. Effective financial support in Nova Scotia would be comparable to California’s, which offers substantial rebates and tax incentives.

Limited progress is evident if Nova Scotia fails to introduce new laws or updates to existing ones. If the legislative landscape remains static while California continues to innovate with aggressive policies (like setting deadlines for phasing out internal combustion engines), Nova Scotia would be lagging. If the subsidies offered in Nova Scotia are not compelling enough to drive significant adoption of EVs, or if they are less generous or less inclusive than those in California, this would represent poor progress. A lack of targeted financial incentives that fail to address key market segments or infrastructure needs would also indicate a shortfall.

Emission Regulations: Good progress is seen when Nova Scotia enforces emissions regulations that are as stringent as or stricter than California’s, which is known for its rigorous environmental standards. This

would mean setting clear, ambitious targets for greenhouse gas (GHG) reductions and ensuring high compliance rates through effective monitoring and penalties. Nova Scotia could demonstrate good progress by not only meeting these standards but also by setting interim targets that push for rapid emission reductions. A high rate of compliance with emissions targets and the active enforcement of penalties for non-compliance would signal strong progress. If Nova Scotia can demonstrate that it's achieving or even exceeding its emissions reduction goals through stringent regulations and effective enforcement, like California's approach, this would be considered good.

If Nova Scotia's emissions regulations are weak, poorly enforced, or not aligned with ambitious reduction goals, this would represent limited progress. For instance, if the standards are much less stringent than California's, which are designed to aggressively curb emissions, Nova Scotia would be falling behind. Poor progress would also be indicated by low compliance rates with emissions targets, suggesting that the regulations in place are either ineffective or inadequately enforced. If companies and industries in Nova Scotia are not held accountable for meeting emissions standards, the province would be making limited progress compared to California.

Energy Policies: Nova Scotia would be making good progress if it sets and actively works towards ambitious renewable energy targets and in line with global best practices, as seen in California. For example, California aims for 100% of its electricity to come from renewable sources by 2045. If Nova Scotia sets a similarly ambitious target and demonstrates clear steps towards achieving it, such as significant investments in renewable infrastructure, this would be positive progress. Good progress is also indicated by consistent, measurable advancements towards these renewable energy goals. This could include significant year-over-year increases in the share of renewables in the energy mix, closure of fossil fuel plants, and investments in new renewable energy projects. If Nova Scotia can show that it's rapidly reducing reliance on non-renewable sources in favor of renewables, this would indicate strong progress.

If Nova Scotia's renewable energy targets are unambitious compared to those in California, or if progress towards these targets is slow or stagnant, this would be considered limited progress. For instance, if the province continues to rely heavily on fossil fuels and makes only minimal investments in renewable energy, it would be falling behind. Poor progress would also be indicated if there is a lack of strong policy support for renewable energy development, such as insufficient incentives or regulatory barriers that slow down the adoption of renewables. If Nova Scotia's policies do not actively promote the growth of renewable energy, especially in comparison to California's aggressive push, it would be seen as making limited progress.

Education and awareness programs: Good progress in this area is characterized by widespread, effective public education and awareness campaigns that reach diverse segments of the population. If Nova Scotia actively engages the public through frequent and impactful campaigns that promote the benefits of EVs, energy efficiency, and sustainability—like California's broad and inclusive outreach efforts—this would be a positive sign. Incorporating EV-related content into school curricula and offering educational programs that raise awareness among younger generations would also signal good progress. If Nova Scotia is making these programs widely available and ensuring that a significant percentage of schools participate, it would be on par with California's efforts to educate and engage its citizens.

Limited progress would be evident if public education and awareness campaigns are limited in scope, infrequent, or fail to resonate with the public. If Nova Scotia's efforts in this area are minimal compared to California's comprehensive approach, the province would be considered to be underperforming. If there are few or no educational initiatives in schools or the initiatives are poorly executed, leading to low levels of awareness and understanding of EVs and renewable energy among students, this would indicate

poor progress. Nova Scotia would be falling behind if it did not invest in educating the next generation about the importance of these technologies, especially when compared to California's proactive approach.

4.2.2 Application of Policy Implementation Metrics on Nova Scotia

The framework for sample metrics for policy implementation indicators will be applied to Nova Scotia. This will involve using available data to track progress in every aspect. Based on this, we can highlight the challenges the province is facing and provide tailored recommendations for improving performance in this indicator. See Table 8 for details.

Table 8 Application of Policy Implementation Metrics on Nova Scotia

Metric	Current Status	Assessment
EV-related legislations passed	Environmental Goals and Climate Change Reduction Act passed in 2021	Positive progress, key legislation in place
Financial incentives available	$3,000 rebate for new BEVs and PHEVs, $1,000-$2,000 for used vehicles; federal $5,000 rebate	Substantial incentives in place, positively impacting adoption
Budget allocation for EV initiatives	$112 million project with contributions from the federal government	Significant funding allocated, positive progress
Stringency of emissions standards	Nova Scotia adheres to stringent federal emissions standards	Leading Canada in GHG reductions, positive progress
Compliance rates with emissions targets	64% of the target of reducing GHG by 53% below 2005 levels by 2030 has been achieved	Ambitious targets set, positive impact on EV adoption
Renewable energy targets	43% of energy from renewables as of now, 80% of electricity from renewable sources by 2030	Ambitious target, positive progress
Progress towards renewable energy goals	53% goal achieved so far. On track to reach 80% electricity generation from renewables by 2030	Positive progress, significant steps towards goals
Incentives for renewable energy	NS net metering scheme, provincial funding for solar homes, and NS community solar	Strong incentives in place

4.2.3 Missing Policy Implementation Metrics

The following metrics are missing from the sample metrics table that was made to assess the progress of Nova Scotia in policy implementation indicator:

Penalties and Enforcement Actions: Lack of detailed data on penalties and enforcement actions related to EV policies and regulations is the reason why this metric is missing. Ensuring compliance with EV-related policies is crucial for their effectiveness. Data on penalties and enforcement actions helps in assessing how well regulations are being followed and enforced.

Number of public awareness campaigns: There is a lack of comprehensive data on the number and reach of public awareness campaigns related to EV adoption and benefits in Nova Scotia. Public

awareness campaigns are essential for educating the population about the benefits of EVs and available incentives. Tracking the number and effectiveness of these campaigns helps in understanding their impact.

EV-related educational initiatives in schools: Limited data on the incorporation of EV-related topics in school curriculums and educational programs is the reason why this metric is missing. Introducing EV-related education in schools helps in fostering a culture of sustainability and awareness from a young age. It prepares the next generation to be knowledgeable about EVs and their benefits.

Public engagement levels: Data on public engagement in EV-related initiatives, forums, and decision-making processes is insufficient. Public engagement is critical for ensuring that policies and initiatives are aligned with the needs and preferences of the community. It enhances the legitimacy and effectiveness of EV policies.

4.2.4 Importance of Addressing the Missing Metrics

Addressing these missing metrics is important for several reasons:

Effective Policy Enforcement: Tracking penalties and enforcement actions ensures that EV-related policies are being followed and can highlight areas where stricter enforcement may be needed:

Reducing Urban Pollution: Monitoring the adoption of low emission zones helps in understanding their impact on urban air quality and in promoting policies that reduce pollution.

Infrastructure Preparedness: Assessing grid readiness is crucial for ensuring that the electric grid can handle increased EV load, thereby preventing outages and ensuring reliable service.

Informed Public: Public awareness campaigns and educational initiatives in schools are essential for creating an informed and supportive population that understands and supports the transition to EVs.

Community Involvement: High levels of public engagement ensure that EV policies and initiatives are responsive to the needs and preferences of the community, thereby increasing their effectiveness and acceptance.

Targeted Education: Understanding current awareness levels helps in designing targeted educational programs that address specific knowledge gaps and misconceptions.

4.3 Assessment of Infrastructure Development in Nova Scotia

The development of infrastructure is crucial for supporting the transition to EVs, influencing the convenience, feasibility, and attractiveness of EV ownership for consumers. In Nova Scotia, the progress in infrastructure development for EVs can be assessed by examining aspects such as charging infrastructure availability, grid capacity and reliability, and the overall landscape of the existing EV facilities.

The availability of charging infrastructure in Nova Scotia has been a focal point of the province's efforts to encourage EV adoption. The government, in partnership with private entities and utility companies, has been working to expand the network of public charging stations across the province. This includes both Level 2 chargers, which offer a convenient option for daily charging needs, and DC fast chargers, which are essential for enabling long-distance travel by reducing charging times significantly (ENS, 2023).

Nova Scotia has recently announced that it will be investing $500,000 towards the installation of more electric vehicle charging stations across the region (Transport Canada, 2024). Natural Resources and Renewables Minister Tory Rushton praised the move, stating that electric vehicles can play a crucial role in reducing emissions and helping the province achieve its goal of a cleaner economy that benefits all Nova Scotians. The investment is in addition to the $1.2 million recently announced by the federal Zero-Emission Vehicle Infrastructure Program, which was administered by Clean Foundation. The foundation sought proposals from organizations to install up to 250 Level 2 electric vehicle chargers in public areas across the province, supporting light-duty vehicles (Transport Canada, 2024).

Additionally, a recent investment of $980,000 has been announced to the HRM, which will install 46 Level-2 and 10 Level-3 fast chargers, totaling 56 chargers at key locations across the region. The installation of these chargers is expected to begin in the spring of 2024, giving EV drivers more confidence and ease when traveling around the region (NRC, 2024). The federal funding for this project was provided through Natural Resources Canada's Zero Emission Vehicle Infrastructure Program, which supports commitments included in Canada's new Electric Vehicle Availability Standard. This Standard aims to increase the supply of clean, zero-emission vehicles across the country and ensure that Canada can achieve a national target of 100 percent of new vehicles being zero-emissions by 2035 (NRCan, 2022). In preparation for this, Canadians can easily map out their route by consulting Natural Resources Canada's electric charger and alternative fueling station locator.

The distribution of charging stations has been strategically planned to cover key routes and locations, aiming to alleviate range anxiety among current and potential EV owners. This expansion not only serves residents but also positions Nova Scotia as a more EV-friendly destination for tourists and visitors driving electric vehicles. See Figure 7.

Figure 7 EV Fast Charging Stations in Nova Scotia (Nova Scotia Power, 2024)

The locations of EV fast-charging stations across the province are shown in Figure 8. The stations are distributed across various counties, indicating an effort to provide geographic coverage for EV drivers. The legend corresponds to the icons on the map, providing details about each charging station's location, often associated with recognizable landmarks or businesses, such as Shell, Sobeys, or Best Western. This is a common approach to facilitate EV users in locating charging stations and to encourage the use of EVs by showing accessible charging options along key travel routes and in various communities.

Despite the significant progress made in developing the infrastructure for EV charging, there are still various challenges that need to be addressed to ensure that the charging network can keep up with the increasing number of EVs on the road. There are areas outside of major cities and along less-traveled routes that still experience gaps in charging availability. This highlights the need for continued investment and strategic placement of new charging stations in these regions. According to recent data, three municipalities –East Hants, Cape Breton, and Chester – have more than 10,500 residents for every public charger available, significantly fewer public chargers per resident compared to other areas (DEC, 2024). This suggests that these areas require more attention and focus in future deployments of public chargers, both to connect them to the network and to support residents who do not have access to home charging.

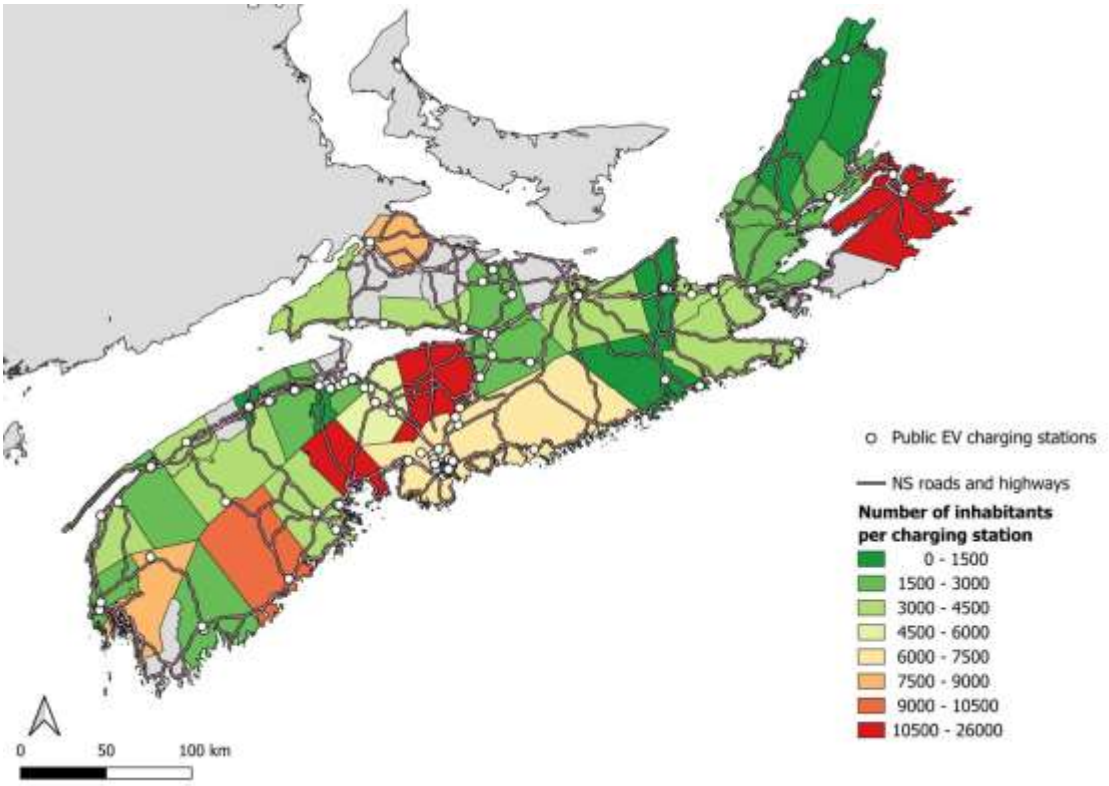

Figure 8 Residents per charging station, by municipality in Nova Scotia (Dunsky, 2023)

Figure 8 shows a significant disparity in the availability of charging infrastructure, with Halifax standing out as the county with the highest number of EV charging stations, exceeding 100. In contrast, many other counties, such as Shelburne, Digby, Guysborough, and Victoria, have very few charging stations, indicating limited public accessibility for EV users in these areas. Kings and Antigonish counties show moderate numbers of charging stations, suggesting some level of infrastructure development. This uneven

distribution of charging stations underscores the challenges in achieving energy security and equity in Nova Scotia's transition to electric vehicles, as rural and less densely populated counties are currently underserved, potentially hindering widespread adoption and equitable access to EV technology across the province. See Figure 9. Several factors contribute to the scarcity of EV charging stations in these areas. Longer distances are typically traveled in rural areas, which might make range anxiety more pronounced. Installing and maintaining EV charging infrastructure can be costly. In rural areas with fewer EV users, the economic return on investment for installing chargers is lower, which can deter businesses and municipalities from investing in this infrastructure. Moreover, government incentives and policies often focus on urban centers where the population density justifies the investment. Rural areas might not receive the same level of attention or funding, leading to slower development of charging infrastructure.

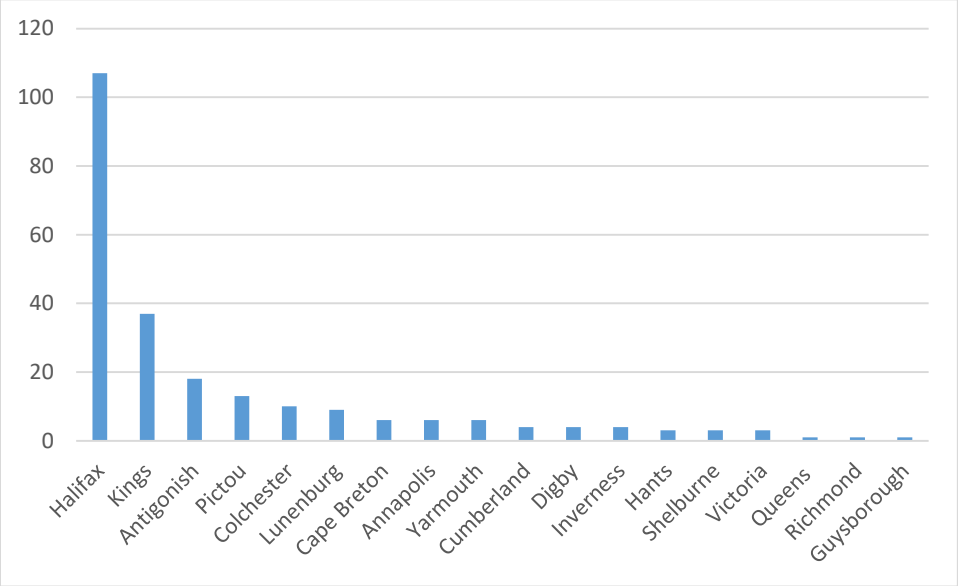

Figure 9 Total number of EV Charging stations across counties in Nova Scotia (EV Hype, 2024)

The integration of EVs into the transportation system has implications for the electrical grid, necessitating assessments of grid capacity and reliability to handle increased demand from EV charging. Nova Scotia Power, the primary electricity provider in the province, has been preparing for the growth in EVs by upgrading grid infrastructure and exploring smart charging solutions that can manage the demand more efficiently (NRCan, 2022). Renewable energy sources, such as wind and hydroelectric power, play a significant role in Nova Scotia's energy mix, contributing to the sustainability of EV charging. Efforts to further green the grid could enhance the environmental benefits of EVs, aligning with the province's climate goals (NRCan, 2022).

4.3.1 Progress Criteria for Infrastructure Development Indicator

For a more subjective assessment of Nova Scotia's progress in comparison to California, we will discuss each metric and identify what constitutes good or limited progress.

Charging infrastructure availability: Good progress would be evident if Nova Scotia develops a charging network that is not only widespread but also accessible to all segments of the population. This would include installing charging stations in urban, suburban, and rural areas, ensuring that no region is underserved. Nova Scotia would be on par with California if it matches the state’s density of charging

stations per capita and their strategic placement, such as along major highways and in key urban centers. Good progress would also include the availability of a variety of charging options, including fast chargers, to meet different needs. If Nova Scotia ensures that EV owners can access fast, reliable charging, like California's extensive network of Level 2 and Level 3 chargers, it would be a positive indicator of progress. Ongoing expansion and innovation in charging infrastructure, such as integrating renewable energy sources or developing ultra-fast charging stations, would also signal good progress. If Nova Scotia is actively expanding its network and adopting the latest technologies, it would reflect a strong commitment to supporting EV adoption.

Limited progress would be characterized by a lack of charging stations, with significant gaps in coverage, particularly in rural areas. If Nova Scotia's charging infrastructure is limited compared to California's extensive network, it would indicate that the province is not adequately supporting EV users. If most available chargers are slow or outdated, this would also reflect poor progress. Nova Scotia would be falling behind if it does not keep pace with California's advancements in fast-charging technology, making EV ownership less convenient and practical. A lack of growth in the number of charging stations or the failure to integrate new technologies would further indicate bad progress. If Nova Scotia's infrastructure development is static or slow, especially in contrast to California's dynamic expansion, it would suggest that the province is not prioritizing EV infrastructure.

Electric grid capacity and reliability: Good progress would be evident if Nova Scotia's electric grid can handle the increased demand from EV charging without compromising reliability. This would include investments in grid upgrades, such as enhancing transformer capacity and improving load management. Nova Scotia would be making good progress if its grid is as robust and resilient as California's, which has been investing heavily in modernizing its electric grid to accommodate renewable energy and EVs. Implementing effective load management programs that prevent grid overload during peak EV charging times would also signal good progress. If Nova Scotia can demonstrate that it is managing peak demand efficiently, like California's use of smart grid technologies and demand response programs, it would indicate a strong infrastructure. A reliable grid with minimal outages, even during high demand periods, would reflect good progress. Nova Scotia would be on the right track if it ensures that EV charging does not lead to increased power disruptions, mirroring California's efforts to maintain grid stability despite its large EV population.

Limited progress would be evident if Nova Scotia's electric grid is frequently strained by EV charging, leading to reliability issues or requiring frequent upgrades. If the grid is not capable of supporting the growing number of EVs without frequent outages or brownouts, it would suggest that the province is not adequately preparing for increased electricity demand. If Nova Scotia lacks effective load management strategies, resulting in frequent peak demand issues or the need for costly emergency measures, this would reflect poor progress. Compared to California's sophisticated grid management systems, any lag in this area would indicate that Nova Scotia is not keeping up. If the introduction of EVs leads to frequent power disruptions or if the grid's reliability decreases as EV adoption grows, this would be a sign of bad progress. Nova Scotia would be underperforming if it cannot maintain or improve grid reliability as EV penetration increases, especially in comparison to California's ability to manage a large EV population with minimal disruptions.

4.3.2 Application of Infrastructure Development Metrics on Nova Scotia

The framework for sample metrics for infrastructure development indicator will be applied to Nova Scotia. Available data will be used to track progress in every aspect. Based on this, we can highlight the

challenges the province is facing and provide tailored recommendations for improving performance in this indicator. See Table 9 for details.

Table 9 Application of Infrastructure Development Metrics on Nova Scotia

Metric	Current Progress	Assessment
Number of public charging stations	236 public charging stations (all levels)	Intermediate progress, more investment required for further growth
Distribution of charging stations in underserved areas	Some areas like East Hants, Cape Breton, and Chester have high residents-per-charger ratios	Gaps exist in underserved areas, needs improvement
Number of fast chargers (DCFC)	26 DCFC fast charging stations with 42 charging ports	Increasing number, but further expansion needed
Grid capacity to support EVs	Nova Scotia Power upgrading grid infrastructure; smart charging solutions explored	Positive steps taken, but future demand will require continued upgrades
Integration of Renewable energy sources	Renewable energy sources like wind and hydro play significant roles; aim for 80% renewable electricity by 2030, currently the share is 43%	Positive progress, aligning with climate goals
Load management programs	Implementation of TOU rates, smart grid technologies, including advanced metering infrastructure (AMI) and demand response management systems (DRMS)	Positive progress, future increasing demand might require upgrades regularly

4.3.3 Missing Metrics of Infrastructure Development

These metrics are missing from the sample metrics table for the infrastructure development indicator:

Investment in Grid Infrastructure: There is a lack of comprehensive data on the current levels of investment in Nova Scotia's electric grid infrastructure. This includes financial commitments made by the government, utilities, and private entities to enhance the grid's capacity, reliability, and resilience. Investment in grid infrastructure is crucial for accommodating the growing demand for electricity, especially with the increasing adoption of electric vehicles (EVs).

4.3.4 Importance of Addressing the Missing Metrics

Addressing these missing metrics is important for several reasons:

Efficient Grid Management: Load management programs and monitoring grid outages help in maintaining a stable and resilient electric grid, which is essential for supporting widespread EV adoption.

Reliability and Trust: Reducing the average downtime of charging stations and improving customer satisfaction with the infrastructure builds trust in the EV ecosystem, encouraging more people to switch to EVs.

4.4 Assessment of Market Penetration in Nova Scotia

Market penetration of EVs is an indicator of how readily consumers are adopting this technology, reflective of both consumer attitudes and the effectiveness of supportive measures. It can be measured by EV sales, adoption rates, and the proportion of EVs compared to the overall vehicle market.

Nova Scotia is one of the provinces in North America where the adoption of EVs has been slow. According to the data from the first quarter of 2024, EVs make up about 4.3% of new vehicle sales in the province, which is significantly lower than leading regions such as British Columbia and Quebec, where the percentage of EVs in the new vehicle sales are 21.9% and 25% respectively (DEC, 2024). From the data available, the biggest market of EVs in the province is in Halifax, as shown in Figure 10. Population and better infrastructure are the main reasons why EV sales in Halifax County are the highest among the other counties. Figure 10 compares the EV rebate registrations among all counties in Nova Scotia from 2021 to 2024.

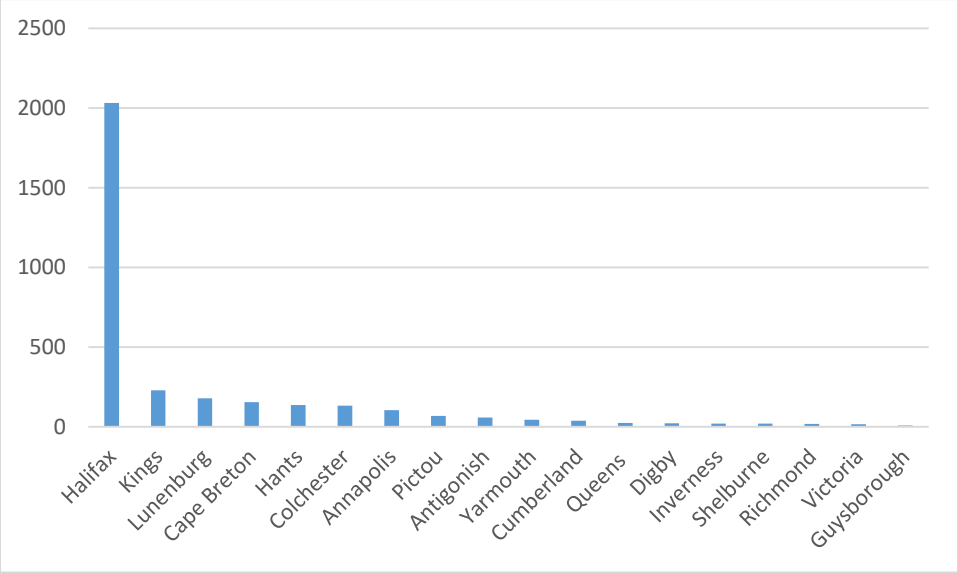

Figure 10 EV rebate registrations by county in Nova Scotia (Access Nova Scotia, 2024)

Data shows that EV rebate registrations are directly related to the infrastructure support in the county. The more charging stations a county has, the better the EV representation. This is the reason why the EV market is mainly saturated in counties with better infrastructure. This relation can be seen in Table 10 which compares the EV registrations in different counties of Nova Scotia with the number of charging stations the county has. Halifax, the largest and most urbanized county in Nova Scotia, has a significantly higher number of EV representation compared to other counties. This can be attributed to several factors. The robust infrastructure is a critical factor that contributes to this EV representation. Being the largest market in Nova Scotia, Halifax has better availability of EVs, both in terms of variety and quantity. This greater availability further drives higher sales. However, high registration figures in Halifax might not accurately represent the number of EVs being used within Halifax itself. Many buyers from other counties travel to Halifax for their purchases due to the lack of local suppliers. The location where EVs are registered provides a more accurate representation of where the vehicles are being used. For example, if a resident from Digby purchases an EV in Halifax but registers and uses it in Digby, the registration data will reflect the actual usage in Digby. Understanding where EVs are registered helps identify the true

adoption rates across different regions. It reveals the geographic spread and allows for better planning of infrastructure and support services. To promote equitable EV adoption across Nova Scotia, it is crucial to establish more local EV dealerships in rural areas. The collection of registration data is crucial to understand the actual distribution of EVs.

The ratio of EV rebate registrations to charging stations is a meaningful metric as it provides insights into the adequacy of charging infrastructure relative to the growing number of EVs. A lower ratio indicates that there are more charging stations available per EV, which generally means better access to charging facilities. Conversely, a higher ratio might indicate potential shortages in charging infrastructure, leading to longer wait times and inconvenience for EV users. Monitoring this ratio helps policymakers and investors identify when and where additional charging infrastructure is needed. It ensures that the growth of the EV market is supported by corresponding growth in charging facilities. A well-balanced ratio contributes to a positive user experience by reducing range anxiety and ensuring that EV owners can find charging stations easily and conveniently.

It is important to note that while this data provides a useful "sanity check" for understanding EV adoption trends across counties, it does have limitations. Specifically, the rebate data does not capture higher-end models that did not qualify for rebates, including all Tesla models for a certain period. Given that Teslas account for at least 50% of the EV market, this omission means that the rebate data underrepresents a significant portion of EV registrations. Therefore, while rebate data is valuable for assessing general trends, it should be interpreted with caution and supplemented with other data sources to provide a more complete picture of EV adoption across the province.

Table 10 EV Rebate Registrations vs EV charging stations in different counties of Nova Scotia

County	EV Rebate Registrations (2021-2024)	Number of EV Charging stations (All Levels)	Ratio of EV Registrations to Charging stations
Halifax	2032	107	18.9
Kings	229	37	6.2
Lunenburg	179	9	19.9
Cape Breton	154	6	25.7
Hants	136	3	45.3
Colchester	132	10	13.2
Annapolis	104	6	17.3
Pictou	68	13	5.2
Antigonish	57	18	3.2
Yarmouth	44	6	7.3
Cumberland	37	4	9.3
Queens	24	1	24
Digby	21	4	5.3
Inverness	20	4	5
Shelburne	19	3	6.3
Richmond	17	1	17
Victoria	16	3	5.3
Guysborough	8	1	6

The distance from an EV owner's home to the nearest public charger is another critical metric, especially from an equity perspective. Shorter distances to public chargers make EV ownership more convenient, particularly for those who do not have the option to install home chargers. This is crucial for residents of apartment buildings or those without dedicated parking spaces. Ensuring equitable access to public charging infrastructure means considering the needs of all community members, including those in underserved or rural areas. If public chargers are predominantly located in affluent or urban areas, it could exacerbate existing inequalities and discourage EV adoption in less advantaged communities. Easy access to public chargers can encourage more people to switch to EVs, knowing that they have convenient charging options even if they cannot charge at home.

Compared to other parts of Canada, Nova Scotia has a relatively limited EV market, and it lags significantly behind other leading markets in Canada. However, among the Atlantic Provinces, Nova Scotia has the highest EV adoption rate (Abotalebi, Scott, & Ferguson, 2019). EV adoption in Canada today is mainly centered in the three provinces that offer purchase incentives for EVs, as well as other supportive policies and investments, namely Quebec, Ontario, and British Columbia (Abotalebi, Scott, & Ferguson, 2019). According to the available data, there has been a significant increase in EV registrations in Nova Scotia. Figure 11 shows the number of EVs registered in the province from 2017 to 2022. As compared to the situation in 2017, EV presence has increased significantly. However, to achieve the 2030 federal ZEV target, it is necessary to a ZEV mandate along with federal and provincial incentives.

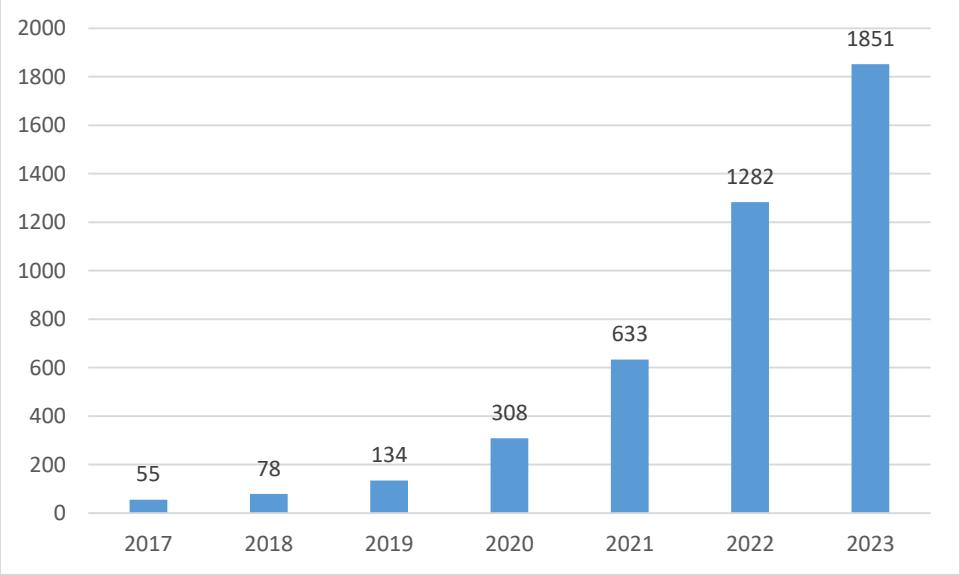

Figure 11 Number of ZEVs registered in Nova Scotia (Statistics Canada, 2023)

However, achieving the forecasted market potential will require continued investment in public infrastructure deployment and favorable market conditions. Although the study emphasizes vehicle purchase incentives and ZEV mandate as key policy interventions, additional measures will be necessary to realize the projected market potential.

4.4.1 Progress Criteria for Market Penetration Indicator

Here is a more detailed evaluation of what constitutes good or limited progress in terms of the market penetration indicator:

EV sales: Good progress in EV sales would be marked by consistent, significant growth year over year. If Nova Scotia shows a steady increase in the percentage of EVs sold relative to total vehicle sales, it would suggest that the province is effectively promoting EV adoption. A high growth rate that approaches or matches California's, where EV sales make up a substantial portion of new vehicle sales, would be a clear sign of success. Another indicator of good progress is the availability of a wide range of EV models that cater to different consumer needs and price points. If Nova Scotia's market reflects a diversity of EVs, including affordable options, luxury vehicles, and commercial models, it would show that the market is maturing and appealing to a broader customer base, like California's diverse EV market. Good progress would also be supported by effective incentive programs that drive EV sales. If Nova Scotia's incentives (rebates, tax credits, etc.) are competitive with those in California and successfully stimulate demand, this would indicate positive progress in market penetration.

Limited progress is evident if EV sales in Nova Scotia are growing slowly or have stagnated. If the percentage of EV sales remains low or grows at a significantly slower pace than in California, it would suggest that the province is struggling to promote EV adoption effectively. A lack of diversity in available EV models would also indicate poor progress. If consumers in Nova Scotia have limited options compared to California, where the market offers a wide range of EVs, this would suggest that the market is not sufficiently developed. If incentive programs in Nova Scotia are not as impactful as those in California, leading to lower-than-expected sales, it will reflect bad progress. For example, if incentives are too small, too restrictive, or poorly communicated, they might fail to drive significant growth in EV sales.

Number of EV chargers: Good progress in the number of EV chargers would be indicated by a rapidly expanding network that meets the needs of the growing EV population. If Nova Scotia is steadily increasing the number of public and private charging stations and keeping pace with the growth in EV sales, it would show strong progress. Matching or exceeding the density of chargers seen in California, particularly in high-demand areas, would be a positive indicator. Good progress would also involve the strategic placement of chargers, ensuring they are accessible in key locations such as urban centers, highways, and rural areas. If Nova Scotia mirrors California's approach of placing chargers where they are most needed, with a focus on high-traffic areas and underserved regions, it would indicate a well-planned infrastructure. Implementing advanced charging technologies, such as ultra-fast chargers and smart grid integration, would further indicate good progress. If Nova Scotia is adopting the latest technologies and expanding its network in line with technological advancements seen in California, it would show a forward-thinking approach.

Limited progress would be evident if the number of EV chargers is not keeping pace with the growth in EV sales, leading to inadequate coverage and longer wait times for charging. If Nova Scotia's network is sparse or poorly maintained compared to California's robust and extensive network, it would suggest the province is lagging. If chargers are not strategically placed, leading to accessibility issues or underutilization, it would indicate bad progress. For instance, if rural areas or key transit routes in Nova Scotia lack sufficient chargers, this would reflect poor planning and hinder overall market penetration. Another sign of bad progress would be the reliance on outdated or slow charging technologies that do not meet the needs of modern EVs. If Nova Scotia's charging infrastructure is less advanced than California's, it would suggest that the province is not investing adequately in keeping up with technological trends.

Overall market adoption rates: Good progress in market adoption rates would be reflected in a high and steadily increasing share of EVs within the total vehicle market. If Nova Scotia achieves a market share that is comparable to or growing towards California's, where EVs represent a significant portion of all vehicles, it would be a strong indicator of successful market penetration. Another indicator of good progress is broad consumer acceptance across different demographics and regions. If EV adoption is widespread in Nova Scotia, reaching various income levels and both urban and rural populations, it would

show that the market is maturing and that EVs are becoming a mainstream choice, like the trend in California. Good progress would also be indicated by the development of a supportive ecosystem that includes not just sales, but also services, maintenance, and aftermarket support for EVs. If Nova Scotia's market ecosystem is as robust as California's, with plenty of service centers, parts availability, and a strong secondary market, it would indicate a healthy, growing market.

Limited progress would be evident if the market share of EVs remains low and shows little sign of growth. If Nova Scotia's adoption rates are far behind those of California, where EVs are becoming increasingly dominant, it would suggest that the market is not developing as it should. If EV adoption is concentrated in specific areas or demographics and fails to reach a broader audience, this would indicate poor progress. For example, if only urban, higher-income consumers are buying EVs while rural and lower-income groups are left out, Nova Scotia's market penetration would be considered weak compared to California's more inclusive adoption. If the supporting ecosystem for EVs in Nova Scotia is underdeveloped, with limited service options, poor aftermarket support, or a lack of secondary market activity, it would reflect bad progress. A weak ecosystem can deter potential buyers and slow overall market growth.

4.4.2 Application of Market Penetration Metrics on Nova Scotia

The framework for sample metrics for market penetration indicator will be applied to Nova Scotia. This will involve using available data to track progress in every aspect. Based on this, we can highlight the challenges the province is facing and provide tailored recommendations for improving performance in this indicator. See Table 11 for details.

Table 11 Application of Market Penetration Metrics on Nova Scotia

Metric	Current Progress	Assessment
Annual EV growth	44% increase in BEVs registered in 2023 as compared to 2022	Yearly growth is satisfactory, but further acceleration would be needed to meet the federal goals
EV market share	4.3% of the new vehicles registered in Q1 2024 were ZEVs	Significantly behind, requires substantial policy support
EV adoption rate compared to the overall vehicle market	The adoption rate dropped by 31.8% in Q1 2024 as compared to Q4 2023	The adoption rate needs improvement
Total number of EVs on the road	Approximately, 7000 EVs on the road as of mid-2024.	Needs considerable growth to meet federal targets
Availability of EV models	Limited availability compared to other provinces like BC, Quebec, and Ontario	Limited model availability, needs expansion
Comparison with National EV Sales	4.3% of the new vehicles registered in Q1 2024 were ZEVs as compared to 12.5% nationally	Lagging behind leading regions significantly
Total number of EV chargers installed	236 EV public charging stations	Intermediate progress, more investment required for further growth

4.4.3 Missing Market Penetration Metrics

The metrics missing from the market penetration indicator are:

Consumer awareness and acceptance rates: Data from surveys or studies measuring the awareness and acceptance of EVs among consumers in Nova Scotia is insufficient. Consumer awareness and acceptance are key indicators of market readiness and potential growth. High levels of awareness and acceptance can drive higher adoption rates, while low levels indicate the need for targeted educational and promotional campaigns.

4.4.4 Importance of Addressing the Missing Metrics

Addressing these missing metrics is important for several reasons:

Improved Infrastructure Planning: Data on the distribution of public vs private chargers helps in ensuring a balanced and accessible charging network, preventing over-reliance on either type.

Enhanced Consumer Outreach: Understanding consumer awareness and acceptance rates allows for the development of targeted educational and marketing campaigns to increase EV adoption.

4.5 Assessment of Equity Consideration in Nova Scotia

Equity consideration is a crucial indicator in assessing the inclusiveness and fairness of the EV transition. It ensures that the benefits of EVs are accessible to all segments of the population, regardless of socio-economic status, geographical location, or other demographic factors. In Nova Scotia, evaluating equity consideration involves examining economic inclusivity, infrastructure distribution, workforce development, and the overall equitable nature of the EV transition.

Economic inclusivity refers to the affordability of EVs for a broad range of income levels. In Nova Scotia, while rebates and incentives are available to reduce the upfront costs of purchasing an EV, it's essential to assess whether these financial measures are sufficient to enable low-to-moderate-income households to participate in the EV market. One of the major obstacles in the widespread adoption of EVs is the higher upfront cost compared to Internal Combustion Engine Vehicles (ICEVs) which is counted to be one of the biggest barriers for low-income communities (Abotalebi, Scott, & Ferguson, 2019).

Additionally, the availability of used EVs in the market, which are often more affordable than new ones, is a critical aspect of economic inclusivity. EV sales data from 2021 to 2024 shows that most of the EVs purchased are new EVs. There can be multiple factors behind this. One of them is the lack of trust from the consumer on the used EV and secondly, its low availability in the market also leaves no other option for the consumer. Figure 12 shows the EV rebate registrations in the province from 2021 to 2024 comparing the rebate registrations of new EVs versus the used EVs.

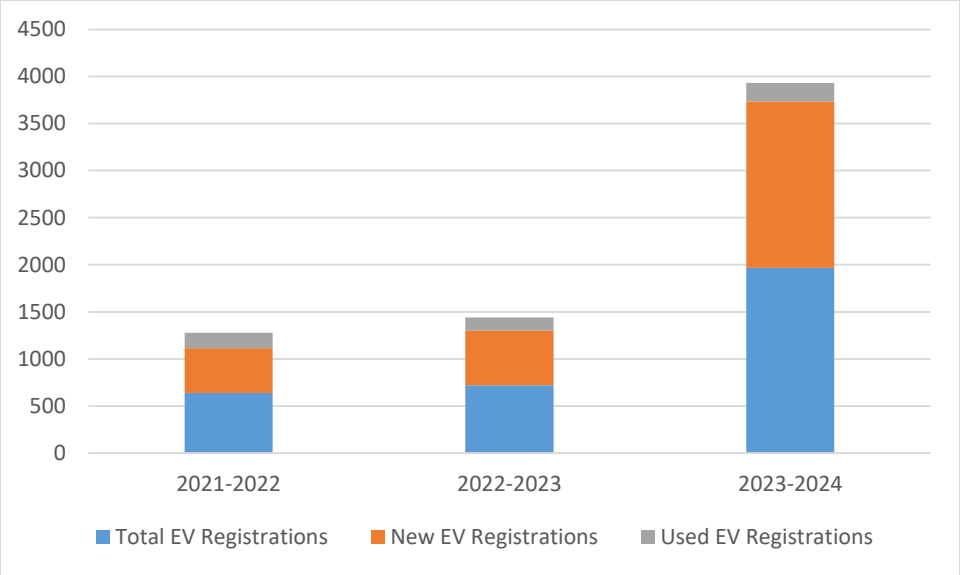

Figure 12 New and used EV rebate registrations in Nova Scotia (2021-2024) (Access Nova Scotia, 2024)

Another dimension to consider is whether the incentives and rebates are reaching a diverse demographic or if they are primarily benefiting a particular group, such as those living in urban centers with higher incomes. The structure of EV incentives may need to be adjusted to ensure broader access and to address disparities in adoption rates across different economic strata. Figure 8 compares the median household income of all counties across Nova Scotia with the number of EV rebate registrations in that respective county. The data reveals that counties such as Halifax and Colchester, which exhibit higher median household incomes (around $60,000 to $70,000), also show a significant number of EV rebate registrations, particularly in Halifax, which stands out with over 2000 EV sales. In contrast, counties with lower median household incomes, such as Shelburne, Guysborough, and Victoria, display minimal to no EV representation. This stark contrast suggests a correlation between household income and EV adoption rates, highlighting the equity issues in Nova Scotia's transition to electric vehicles. Higher-income counties have better access to EVs, while lower-income areas lag, potentially due to the higher upfront costs of EVs and limited financial incentives. This disparity underscores the need for targeted policies and investments to ensure equitable access to EV technology across all socioeconomic groups, aligning with the broader goals of energy security and equity in the province's EV transition strategy.

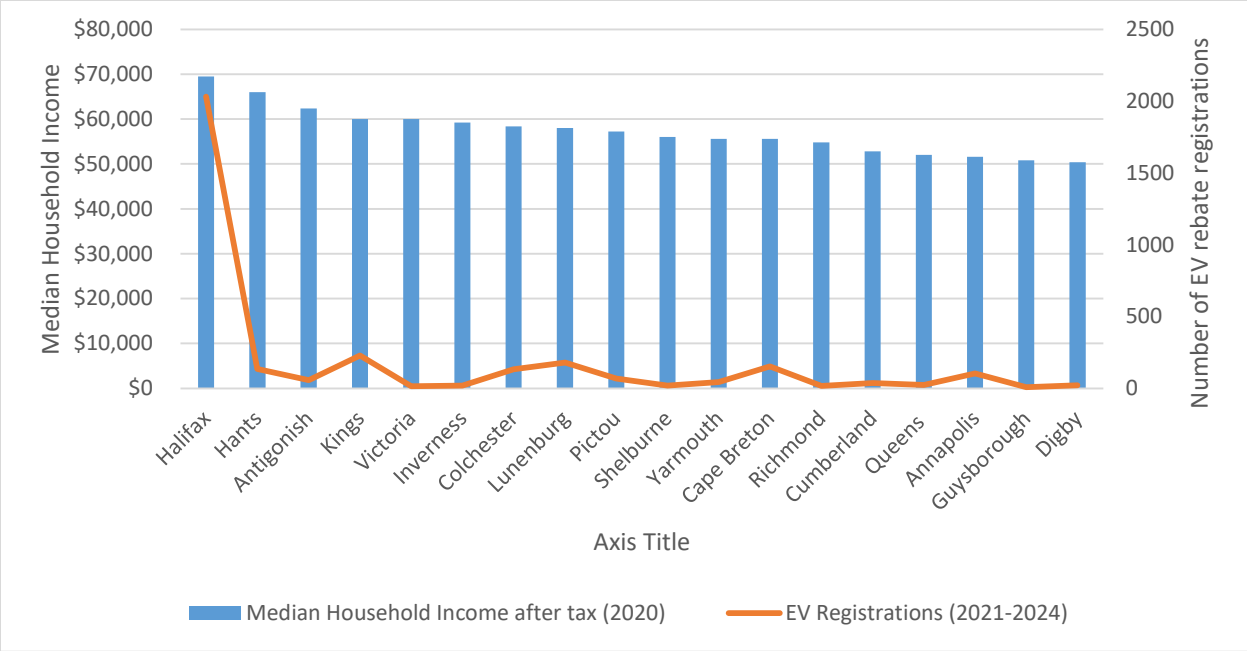

Figure 13 Median Household income of Counties vs EV rebate registrations in Nova Scotia (Access Nova Scotia, 2024)

It has been observed that several states in the United States with comparable vehicle markets to Nova Scotia have successfully implemented a ZEV mandate. For instance, Maine, Rhode Island, and Vermont have implemented such a mandate (Abotalebi, Scott, & Ferguson, 2019). It is noteworthy that all the states and provinces that have adopted a ZEV mandate have also implemented demand-side policies, such as financial incentives. These policies are aimed at ensuring that there is adequate consumer demand to meet the supply targets set by the mandate. Keeping this in consideration, it has been suggested by several stakeholders in Nova Scotia that the province would benefit immensely from the implementation of a ZEV mandate (Ecology Action Centre, 2020). Stakeholders include Ecology Action Centre, Clean Foundation and Government of Nova Scotia. These programs, in combination with parallel efforts towards education and charging infrastructure deployment, would stimulate strong consumer demand for EVs (NRC, 2024). Additionally, a ZEV mandate would ensure that interested consumers would find EVs readily available for purchase in local automotive dealerships in sufficient supply to satisfy that demand.

The distribution of charging infrastructure is a critical factor in assessing equity. It's not just the quantity of charging stations that matters but their location as well. For equitable access, charging infrastructure must be evenly distributed across both urban and rural areas, ensuring that residents in all regions have the same opportunities to charge their vehicles. This includes the availability of public charging stations in apartment complexes, low-income neighborhoods, and remote communities. Upon examining the locations of First Nations communities and reserves, it has been noticed that there may be some gaps in the EV infrastructure network (DEC, 2024). See Figure 14. It is imperative to conduct further engagement with the members of these communities to gain a better understanding of their local needs and their desired approach to the installation and operation of additional charging infrastructure in the area. This will help ensure that the EV infrastructure network is efficiently developed and can cater to the needs of everyone in the community.

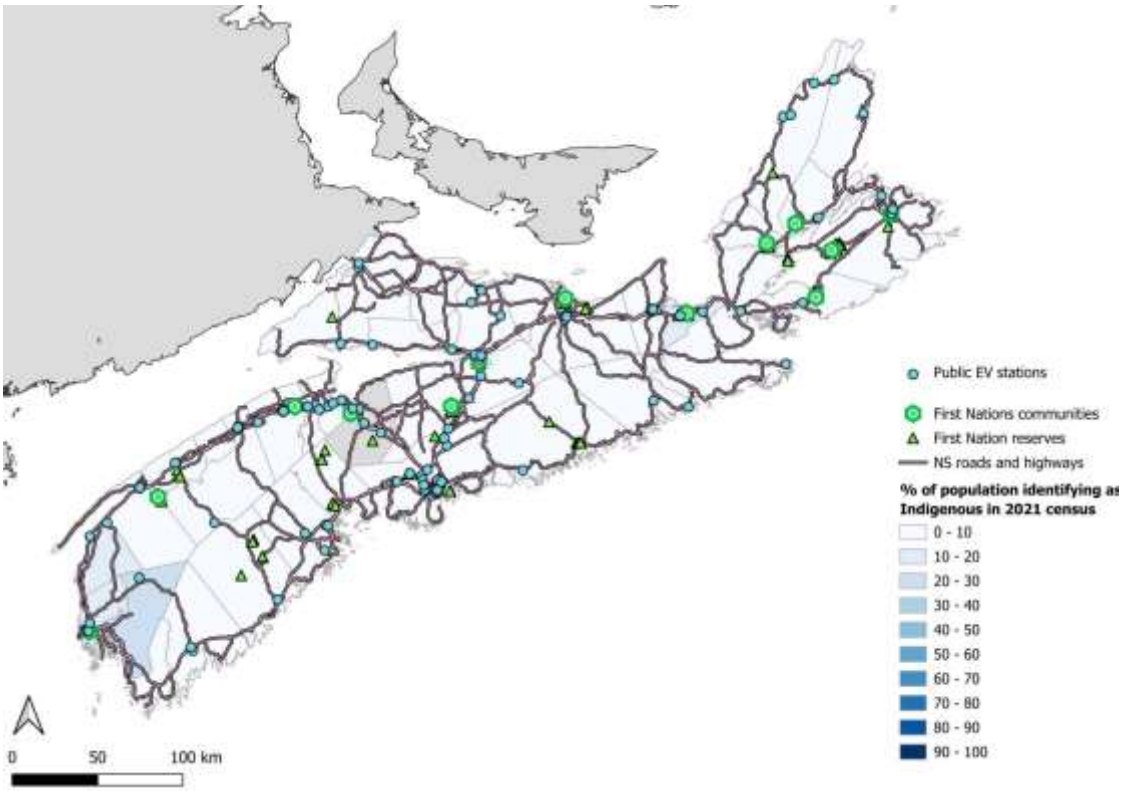

Figure 14 First Nations population along with Public EV Stations (DEC, 2024)

Figure 14 illustrates the distribution of public EV charging stations in relation to First Nations communities and reserves, overlaid with demographic information based on the percentage of the population identifying as Indigenous in the 2021 census. It serves as a visual tool to evaluate the public accessibility of EV charging infrastructure for indigenous populations and to assess the geographic and demographic equity of EV infrastructure development. It can be used to identify areas where there may be gaps in charging station coverage, particularly in regions with higher percentages of Indigenous populations, which is pertinent for discussions around equity consideration in the transition to EVs. To ensure equitable access to EV infrastructure, it is crucial to fill out these gaps in First Nation communities as well or else it would exacerbate geographical disparities in EV adoption.

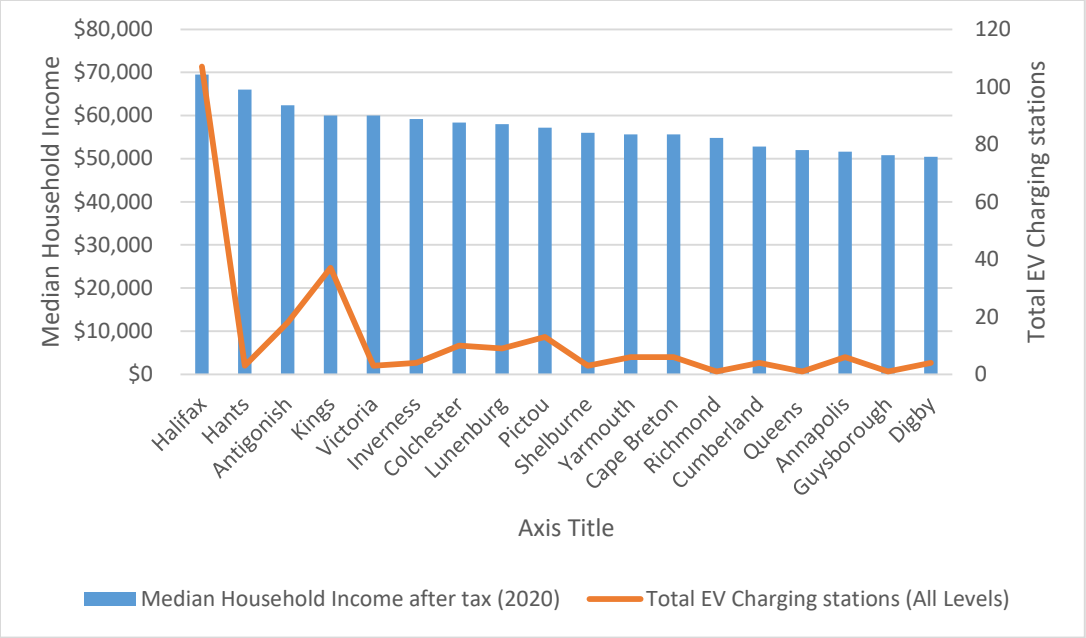

Figure 15 Median Household Income of counties vs the Number of EV Charging stations in Nova Scotia (Statisics Canada, 2022)

Figure 15 shows that Halifax, with the highest number of EV charging stations (over 100), also has a high median household income, of approximately $70,000. In contrast, counties such as Shelburne, Digby, and Guysborough have both lower household incomes and fewer charging stations, highlighting a significant disparity. Other counties like Colchester and Antigonish show moderate levels of income and infrastructure, indicating some degree of EV support but still lacking compared to Halifax. This comparison underscores the equity issues in Nova Scotia's EV transition, where higher-income counties tend to have better access to EV charging infrastructure. There is a need for more balanced investment in EV infrastructure across all regions to ensure equitable access and support the broader goals of energy security and sustainability in Nova Scotia's transition to electric vehicles.

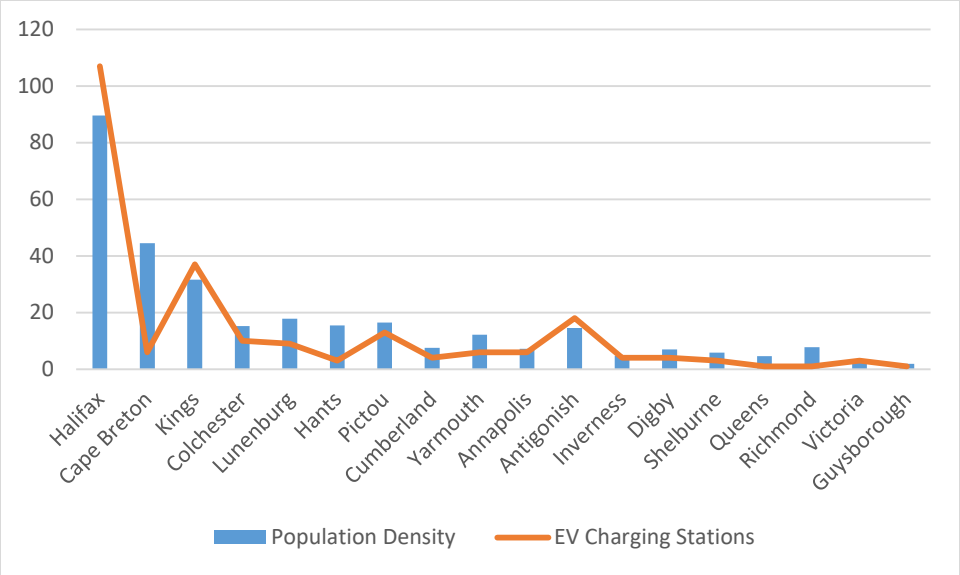

Figure 16 Population density of counties vs Number of EV charging stations (Nova Scotia Government, 2023)

Figure 16 illustrates a comparison between the population densities of various counties across Nova Scotia as of July 1, 2023, and the corresponding number of EV charging stations within those counties. The blue bars represent the population density (measured as people per square kilometer), while the orange line represents the number of EV charging stations available in each county. Following are some of the key observations that can be drawn from Figure 16:

- Halifax, the most densely populated county, shows a significantly higher population density compared to other counties. However, the number of EV charging stations does not increase proportionally. This suggests that while Halifax has the highest concentration of residents, the growth in EV charging infrastructure has not fully matched this density, potentially indicating a gap in infrastructure relative to the population.
- Both Cape Breton and Kings Counties have moderate population densities but show relatively fewer EV charging stations. This might suggest an underinvestment in charging infrastructure in these areas, which could impact EV adoption rates.
- Counties such as Colchester and Pictou show a closer alignment between population density and the number of charging stations, reflecting a more balanced distribution of infrastructure. However, in less populated counties like Richmond, Victoria, and Guysborough, the number of charging stations is low, which might be expected given their lower population densities, but it also raises concerns about accessibility for residents in these areas.

4.5.1 Progress Criteria for Equity Consideration Indicator

To provide a more subjective assessment of Nova Scotia's progress as compared to California, we can look at each metric and determine what constitutes good or limited progress:

Economic Inclusivity: Good progress in economic inclusivity would mean that EV ownership and benefits are accessible to a wide range of income levels. If Nova Scotia ensures that lower-income households have access to affordable EVs through subsidies, incentives, or financing options, it would

reflect positively. California's approach, which includes targeted rebates for low-income buyers, could serve as a benchmark. Good progress in Nova Scotia would involve similar initiatives that ensure economic barriers do not prevent people from adopting EVs. If Nova Scotia implements policies specifically designed to support low-income communities, such as additional rebates, reduced electricity rates for EV charging, or community charging hubs, it would show good progress. Such measures would ensure that the economic benefits of EV adoption, like reduced fuel and maintenance costs, are available to everyone, not just higher-income households. Good progress would also involve programs that support the second-hand EV market, making EVs more affordable and accessible to a broader population. If Nova Scotia develops a thriving second-hand EV market, ensuring that even those who cannot afford new EVs can participate in the transition, it would reflect a commitment to economic inclusivity.

Limited progress in economic inclusivity would be indicated by high-cost barriers that limit EV adoption to higher-income individuals. If Nova Scotia does not offer sufficient incentives or financing options to make EVs affordable for lower-income households, it would suggest that the transition to EVs is economically exclusive. This would contrast sharply with California's efforts to make EVs accessible across all income levels. If there is a lack of targeted support for low-income communities, such as inadequate subsidies or high electricity costs for EV charging, it would reflect poor progress. Without these supports, lower-income households may be excluded from the benefits of EV ownership, leading to inequitable outcomes. If there is a lack of affordable EV options or a weak second-hand market in Nova Scotia, it would indicate bad progress. High prices and limited options would prevent lower-income individuals from accessing EVs, making the transition to clean transportation economically exclusive.

Infrastructure distribution: Good progress in infrastructure distribution would involve an equitable spread of charging infrastructure across all regions, including rural and underserved areas. If Nova Scotia ensures that charging stations are not concentrated only in affluent or urban areas but are evenly distributed, like California's efforts, it would reflect a commitment to equitable access. Good progress would also include a focus on installing chargers in underserved communities, ensuring that these areas are not left behind in the EV transition. If Nova Scotia prioritizes infrastructure development in areas with lower access to transportation options or in regions that have been historically underserved, it would demonstrate an equitable approach to infrastructure distribution. Ensuring that charging infrastructure is accessible to all populations, including those with disabilities, would be another sign of good progress. If Nova Scotia implements inclusive design standards for charging stations, like those in California, it would show that the province is prioritizing equity in infrastructure development.

Limited progress would be indicated by a concentration of charging infrastructure in affluent or urban areas, leaving rural or low-income communities underserved. If Nova Scotia's infrastructure development is uneven, with significant gaps in rural or disadvantaged areas, it would suggest that the province is not prioritizing equity in its EV infrastructure. If underserved regions are neglected in infrastructure planning, it would reflect poor progress. This could lead to a situation where certain populations are unable to participate in the EV transition due to lack of access to charging facilities, further exacerbating existing inequities. If charging stations are not accessible to all populations, such as those with disabilities, it would indicate bad progress. Inaccessible infrastructure would prevent certain groups from adopting EVs, undermining the goal of equitable access to clean transportation.

Workforce development: Good progress in workforce development would involve comprehensive training programs that prepare workers for jobs in the EV industry. If Nova Scotia invests in training and education programs that equip workers with the skills needed for EV manufacturing, maintenance, and infrastructure development, similar to California's initiatives, it would reflect a commitment to building a skilled workforce for the future. Good progress would also involve creating job opportunities that are

accessible to a diverse range of people, including those from disadvantaged communities. If Nova Scotia ensures that workforce development programs are inclusive and provide pathways for marginalized groups to enter the EV industry, it would show that the province is prioritizing equity in its economic development. Providing support for workers transitioning from traditional automotive or energy sectors to the EV industry would be another indicator of good progress. If Nova Scotia offers retraining programs or other support mechanisms for workers impacted by the shift to EVs, it would demonstrate a commitment to a just transition.

Limited progress would be evident if there are limited or inadequate training programs to prepare the workforce for jobs in the EV industry. If Nova Scotia does not invest in workforce development, it would suggest that the province is not adequately preparing for the economic shifts associated with the EV transition. If workforce development programs are not inclusive, leaving out marginalized communities or failing to provide opportunities for disadvantaged groups, it would reflect poor progress. Without inclusive programs, the benefits of job creation in the EV industry may not reach all segments of the population, leading to inequitable outcomes. If Nova Scotia fails to provide support for workers transitioning from traditional sectors to the EV industry, it would indicate bad progress. This could result in economic hardship for workers displaced by the shift to EVs and undermine the goal of a just transition.

4.5.2 Application of Equity Consideration Metrics on Nova Scotia

The framework for sample metrics for equity consideration indicator will be applied to Nova Scotia. This will involve using available data to track progress in every aspect. Based on this, we can highlight the challenges the province is facing and provide tailored recommendations for improving performance in this indicator. See Table 12 for details.

Table 12 Application of Equity Consideration Metrics on Nova Scotia

Metric	Current Progress	Assessment
Affordability of EVs	EVs are currently less affordable due to high upfront costs. Rebates exist but may not be sufficient for low-income households	Needs stronger financial incentives targeted at lower-income households
Geographic distribution of charging stations	Gaps identified in rural areas and First Nations communities	Need to expand infrastructure to underserved areas, including rural and Indigenous communities
Training programs for EV-related jobs	Limited training available for dealership staff and service technicians, few courses offered by NSCC	Expand training programs to increase workforce readiness for EVs

4.5.3 Missing Equity Consideration Metrics

Following are the metrics that are missing from the sample metrics table that was made to assess the progress of Nova Scotia in equity consideration indicator:

Subsidy Distribution: There is a lack of detailed data on how subsidies are distributed across different socioeconomic groups and geographic areas within Nova Scotia. Understanding the distribution of subsidies is crucial to ensure that financial assistance reaches those who need it most, particularly low-

income households and underrepresented communities. Equitable distribution of subsidies can help to bridge the gap in EV adoption rates among different demographic groups.

Diversity in EV Workforce: There is a limited amount of data on the diversity (e.g., gender, race, socioeconomic background) of individuals employed in the EV industry within Nova Scotia. Promoting diversity in the EV workforce can lead to more innovative solutions and inclusive practices. It also ensures that the benefits of the growing EV industry are shared across different demographic groups, promoting social equity.

4.5.4 Importance of Addressing the Missing Metrics

Addressing these missing metrics is important for several reasons:

Promotes Fairness and Inclusivity: Ensuring equitable distribution of subsidies and promoting diversity in the workforce helps to create a more inclusive and fair EV ecosystem.

Enhances Community Support: Effective community engagement and support for small businesses build local support and trust, which are essential for the successful implementation of EV initiatives.

Stimulates Economic Growth: Supporting small and local businesses can drive economic growth and job creation, ensuring that the benefits of the EV transition are widely distributed.

4.6 Chapter Summary

The transition to electric vehicles (EVs) in Nova Scotia is a crucial component of the province's strategy to reduce greenhouse gas emissions and promote sustainable transportation. However, for this transition to be truly successful, it must be equitable, ensuring that all communities benefit from the shift to EVs. This chapter has evaluated Nova Scotia's progress using comprehensive metrics across four key areas: policy implementation, infrastructure development, market penetration, and equity considerations. Special attention is given to identifying gaps in data and understanding their implications for achieving equity.

Metrics for policy implementation are essential for creating informed policies that ensure equitable access to the benefits of EVs, including clean air and economic opportunities. Infrastructure development metrics ensure widespread, reliable, and user-friendly charging infrastructure, which is critical for equitable EV adoption, particularly in underserved areas. Market penetration metrics help identify barriers to EV adoption and ensure that incentives are reaching those who need them most, promoting equity. Equity Consideration metrics are crucial for ensuring that the benefits of the EV transition are shared equitably across all communities, particularly marginalized groups. They help address disparities in access to EV technology, financial benefits, and employment opportunities.

Throughout this chapter, the need for equity is a recurring theme. Each set of metrics is not only an indicator of progress but also a measure of how well the benefits of EV adoption are distributed among all segments of society. By enhancing data collection and analysis across policy implementation, infrastructure development, market penetration, and equity consideration the province can ensure that the shift to EVs benefits everyone, implementing a more inclusive, sustainable, and resilient transportation system.

5. RESULTS AND DISCUSSION

This chapter will focus on the direct comparison between Nova Scotia and California across the four indicators Policy Implementation, Infrastructure Development, Market Penetration, and Equity Consideration using the data from the literature review and case study. The discussion will highlight areas where Nova Scotia is lagging, reasons for these shortcomings, recommendations across every indicator for the policymakers in Nova Scotia, and key lessons learned from California's approach to EV adoption that can be applied in Nova Scotia to address these identified gaps.

5.1 Policy Implementation

The main highlights of California and Nova Scotia's overall progress according to the Policy Implementation indicator will be compared to perform a comparative analysis and identify the gaps in Nova Scotia's policies. By this comparison, recommendations to improve the province's progress in this indicator will be made.

5.1.1 California

California has taken a comprehensive and multi-faceted approach to policy implementation, focusing on stringent regulations, substantial incentives, and innovative programs that collectively drive the adoption of electric vehicles (EVs) across the state. Following are some of the significant steps:

Regulatory Framework: California has implemented aggressive regulations, such as the Zero Emission Vehicle (ZEV) mandate (California Air Resource Board, 2022), requiring automakers to sell a certain percentage of electric vehicles.

Incentives: The state offers substantial financial incentives, including up to $7,500 in federal tax credits and additional state rebates up to $2,500 for new EV purchases (CARB, 2023).

Comprehensive Programs: Programs like the California Clean Fuel Reward provide additional incentives at the point of sale, and the Low Carbon Fuel Standard (LCFS) encourages the use of cleaner fuels (CARB, 2022)

5.1.2 Nova Scotia

Following are the main highlights of Nova Scotia's performance in policy implementation indicator:

Regulatory Framework: Nova Scotia lacks a robust ZEV mandate, relying primarily on federal policies and targets. The existing rebates are funded by the provincial government.

Incentives: The province provides rebates for EV purchases, but they are generally lower than California's. For example, the EV Boost program offers rebates for Level 2 charging infrastructure but is less comprehensive in scope.

Programs: Initiatives like Efficiency Nova Scotia's EV charging rebates are a positive step, but there is a lack of integrated and extensive programs as compared to California.

5.1.3 Comparative Analysis and Recommendations for Improvement

California has implemented comprehensive policies to encourage EV adoption, including strict emissions regulations, financial incentives, and significant investment in public awareness campaigns. Penalties and enforcement actions are well-documented, and major cities are actively adopting low-emission zones. In contrast, Nova Scotia's policy framework is less developed, with gaps in data on enforcement actions and

public awareness campaigns. The absence of detailed metrics on grid readiness and educational initiatives in schools further highlights the need for more robust policy measures in Nova Scotia to match California's progress.

The following are the recommendations that should be applied in Nova Scotia after examining the province's progress in the policy implementation indicator as compared to California:

Detailed Tracking and Reporting: Implement mechanisms to track and report data on public awareness campaigns, educational initiatives, and community engagement efforts to assess progress in these areas better.

Expand Accessibility and Equity: Ensure financial incentives and infrastructure development programs are accessible to all income groups, including low- and middle-income households, to enhance economic inclusivity.

Enhance Public Engagement: Increase the number of public engagement events and educational programs to raise awareness about the benefits of EVs and available incentives.

Monitor and Adjust Emissions Regulations: Continue to monitor compliance with emissions regulations and adjust policies as needed to ensure progress towards the province's ambitious climate goals.

5.2 Infrastructure Development

In this section, the infrastructure development indicators of California and Nova Scotia will be compared to analyze their overall progress and identify the gaps in Nova Scotia's policies. This comparative analysis will help us provide specific recommendations to improve the province's performance in this indicator.

5.2.1 California

California's commitment to expanding electric vehicle infrastructure is evident through substantial investments and strategic partnerships, ensuring a well-developed and accessible charging network across the state. Following are some of the significant initiatives taken:

Charging Stations: California has invested heavily in EV infrastructure, with over 70,000 Level 2 and DC fast chargers across the state.

Public and Private Partnerships: The state collaborates with private companies to expand the charging network, ensuring widespread coverage, including rural and underserved areas.

Innovative Solutions: Multiple programs like the Electric Vehicle Infrastructure Training Program (EVITP) train contractors and electricians, ensuring a skilled workforce to support infrastructure development.

5.2.2 Nova Scotia

Following list indicates the main highlights of Nova Scotia's performance in Infrastructure Development indicator:

Charging Stations: The province must invest in charging stations and the significant gaps in rural areas need to be addressed. As of 2024, there are 236 public EV charging stations in the province across all counties.

Public Initiatives: Recent initiatives aim to improve infrastructure, such as Efficiency Nova Scotia's charging rebates and Halifax Regional Municipality's plans to install public fast-charging stations. The Efficiency Nova Scotia's Charging Rebates program is supported by a combination of provincial funds and contributions from private sector stakeholders, including utility companies and automotive industry partners. These collaborations help subsidize the cost of home and commercial EV chargers, making it more affordable for consumers and businesses to adopt EV technology. The installation of HRM's public fast charging stations is funded by municipal budgets, provincial and federal grants, and partnerships with private companies. For example, Natural Resources Canada's Zero-Emission Vehicle Infrastructure Program (ZEVIP) grants support the deployment of EV charging infrastructure across the country, including in Nova Scotia. Additionally, private sector investment from companies in the automotive and energy sectors helps cover the costs associated with these projects.

Investment Gaps: Overall investment in charging infrastructure is lower, and there is less emphasis on training and workforce development. Nova Scotia Community College (NSCC) does have training programs that touch upon aspects of Electric Vehicle (EV) technology. The Electrical Technician program at NSCC includes training in alternative electrical energy systems, such as solar photovoltaic, wind, and smart grid technologies, which are integral to the infrastructure supporting EVs (NSCC, 2023). Additionally, the Automotive Service and Repair program covers the mechanical and electrical systems of vehicles, equipping students with skills relevant to EV maintenance and repair (NSCC, 2023).

While these programs provide a foundation, Nova Scotia could benefit from the introduction of more specialized EV training programs to enhance the overall adoption and support of electric vehicles in the province. This is especially important when compared to places like California, where robust EV mandates and extensive training programs have significantly advanced EV adoption. Expanding and intensifying such programs in Nova Scotia would help bridge the gap and accelerate the province's transition to a greener transportation system.

5.2.3 Comparative Analysis and Recommendations for Improvement

California leads in EV infrastructure development with an extensive residential and public charging station network, supported by advanced load management programs to ensure grid stability. Data on the average downtime of charging stations and customer satisfaction is readily available, allowing for continuous improvement. Nova Scotia, however, lags with fewer residential chargers, less comprehensive load management programs, and limited information on charging station reliability and user satisfaction. Addressing these gaps is crucial for Nova Scotia to enhance its EV infrastructure and support equitable access.

After carefully examining the progress of both California and Nova Scotia according to the infrastructure development indicator, given below are some recommendations:

Expand Charging Infrastructure: Focus on increasing the number of charging stations in underserved areas to ensure equitable access. Continue to build partnerships with private entities and utility companies to support this expansion.

Enhance Grid Capacity: Invest in smart grid technologies and demand response programs to manage the increased load from EVs. Continue upgrading grid infrastructure to handle future demand. Nova Scotia Power is working in conjunction with Efficiency Nova Scotia on initiatives like the Critical Peak Price (CPP) Tariff to manage energy demand (NSP, 2024). This tariff is designed to encourage customers to shift their energy use away from peak periods when demand is highest, thus helping to stabilize the grid and reduce the need for additional power generation during those times. Customers on the CPP rate plan are notified of critical peak events and charged higher rates during these periods, incentivizing them

to reduce consumption during peak hours (Whited, 2021). These efforts highlight the need for more investment in smart grid technologies and demand response programs to manage the increased load from EVs and continue upgrading grid infrastructure to handle future demand.

Improve Data Collection: Implement mechanisms to track and report data on the number of EV service centers, maintenance services, and EV-friendly amenities. This will help identify gaps and areas for improvement.

Increase Public Awareness: Promote the availability of new charging stations and educate the public on the benefits of EVs and the support available for EV adoption.

5.3 Market Penetration

The primary highlights of California and Nova Scotia's overall progress, as assessed by the market penetration indicator, will be compared to conduct a comparative analysis and identify gaps in Nova Scotia's policies. Based on this comparison, tailored recommendations will be provided to enhance the province's performance in this area.

5.3.1 California

California's leadership in electric vehicle adoption is driven by high market penetration, diverse model availability, and effective consumer awareness efforts, making it a front-runner in the transition to zero-emission vehicles. Following points highlight California's performance:

Adoption Rates: California leads the U.S. with 21.1% of new car sales being ZEVs in 2023, supported by strong incentives and infrastructure.

Model Availability: A wide variety of EV models are available, driven by the ZEV mandate and partnerships with automakers.

Consumer Awareness: Extensive public awareness campaigns and EV showcases increase consumer knowledge and interest.

5.3.2 Nova Scotia

Following are Nova Scotia's performance highlights in market penetration indicator:

Adoption Rates: EVs make up about 4.3% of new vehicle sales in Nova Scotia in the first quarter of 2024 which is far below California's levels.

Model Availability: Limited availability of ZEV models, with longer wait times and fewer choices compared with provinces like Quebec and British Columbia.

Consumer Awareness: Public awareness efforts are less comprehensive, contributing to lower consumer interest and understanding. A study conducted by the Ecology Action Centre highlighted the need for increased public awareness and education to boost EV adoption in Nova Scotia. The report emphasizes that many residents are not fully informed about the benefits and practicality of EVs, which hampers their willingness to switch from traditional vehicles (Dunsky Energy Consultation, 2020).

5.3.3 Comparative Analysis and Recommendations for Improvement

In terms of market penetration, California boasts high consumer awareness and acceptance rates, driven by widespread incentives and a robust public vs. private charger distribution. Detailed data on incentive utilization rates ensure that financial benefits reach diverse demographics. Nova Scotia, on the other hand, struggles with lower public awareness and acceptance rates, and lacks detailed data on the distribution

and utilization of incentives. Improving market penetration metrics in Nova Scotia will require targeted efforts to educate the public and streamline incentive programs.

Here are the suggested recommendations based on the province's market penetration indicator performance compared to California:

Increase Financial Incentives: Expand provincial rebates to lower the cost barrier for EV adoption for low-income Nova Scotians.
Implement ZEV Mandates: Introduce a provincial ZEV mandate to ensure that the committed target of 30% new car sales in Nova Scotia to be EVs by 2030 can be met. This can help increase the availability and diversity of EV models.
Promote Public Awareness: Enhance education and awareness programs to inform the public about the benefits of EVs and the available incentives. This can include marketing campaigns, workshops, and community events.
Expand Charging Infrastructure: Continue to invest in public charging infrastructure, particularly in underserved areas, to alleviate range anxiety and make EVs a more convenient option for consumers.
Support EV-Friendly Policies: Implement policies that support the deployment of EVs as they are essential for reducing emissions, fostering economic development, ensuring energy security and help the province align with the global trends of emission reduction.

5.4 Equity Considerations

The main aspects of California and Nova Scotia's overall progress, as assessed by the equity consideration indicator, will be compared to conduct a comparative analysis. This analysis aims to identify disparities in Nova Scotia's policies. Based on this comparison, specific recommendations will be provided to enhance the province's performance in this indicator.

5.4.1 California’s Progress

California's approach to electric vehicle adoption is deeply rooted in equity, with targeted incentives and inclusive programs designed to ensure that all communities, particularly disadvantaged and rural areas, benefit from the state's transition to clean transportation. Following list indicates California’s performance:

Targeted Incentives: Programs like the California Clean Vehicle Rebate Project (CVRP) offer higher rebates for low-income households and ensure incentives reach disadvantaged communities.

Geographic Equity: Efforts to ensure equitable distribution of charging infrastructure, with initiatives focusing on low-income and rural areas.

Inclusive Programs: Equity programs within EV policies ensure that benefits reach all demographics, addressing socio-economic disparities.

5.4.2 Nova Scotia’s Progress

Following list shows Nova Scotia’s performance highlights in equity consideration indicator:

Limited Equity Focus: Current policies lack targeted incentives for low-income households and disadvantaged communities.

Infrastructure Gaps: Charging infrastructure is unevenly distributed, with rural and low-income areas facing significant access barriers.

Equity Programs: There are fewer programs specifically addressing equity issues in EV adoption, resulting in less inclusive benefits.

5.4.3 Comparative Analysis and Recommendations for Improvement

California's approach to equity in EV adoption includes targeted subsidy distribution, strong community engagement initiatives, a diverse EV workforce, and support for small and local businesses. Detailed metrics in these areas ensure that the benefits of EV adoption are equitably shared across different communities. Nova Scotia, however, lacks comprehensive data on subsidy distribution, community engagement, workforce diversity, and support for local businesses. To achieve equitable EV adoption, Nova Scotia must prioritize these areas, ensuring that all communities benefit from the transition to electric vehicles.

Given below are the recommendations for improvement of Nova Scotia in the equity consideration indicator:

Strengthen Financial Incentives: Implement targeted financial incentives for low-to-moderate-income households to make EVs more affordable. This can include higher rebates for used EVs and upfront purchase incentives to directly address the high initial cost.
Expand Charging Infrastructure: Invest in the deployment of charging stations in rural areas, low-income neighborhoods, and First Nations communities to ensure equitable access. Engage with local communities to identify optimal locations and address specific needs.
Enhance Workforce Training: Develop and promote training programs for EV maintenance and service, ensuring they are accessible to a diverse range of individuals. Encourage dealerships to invest in the necessary tools and infrastructure to support EV sales and service. This will help address equity issues by providing job opportunities, supporting local economic growth, improving consumer confidence, and ensuring a sustainable and inclusive transition to electric vehicles. This approach not only enhances the overall adoption of EVs but also ensures that the benefits of this transition are shared equitably among all residents of Nova Scotia.
Implement ZEV Mandates and Policies: Introduce provincial ZEV mandates in combination with financial incentives to increase the availability of EVs in local car dealerships. This can help meet the supply targets and stimulate consumer demand for EVs. Evidence from California and Quebec demonstrates that this approach leads to higher EV adoption rates by ensuring a consistent supply of EVs and making them financially attractive to consumers. Quebec, with a ZEV mandate, has seen substantial growth in its EV market. The mandate ensures a steady supply of EVs, and provincial incentives further encourage consumer adoption. This dual approach has resulted in Quebec having one of the highest rates of EV adoption in Canada (Jarrat, 2024 EV charging networks report, 2024).
Promote Public Awareness and Education: Increase awareness about the benefits of EVs and available incentives through targeted education campaigns. This can include outreach programs in low-income and rural communities to ensure all segments of the population are informed about EV opportunities.
Improve Incentive Utilization Tracking: Improving incentive utilization tracking in Nova Scotia involves implementing a more comprehensive and systematic approach to collect, analyze, and report data on how incentives are being used. Although some strategies can be used to improve incentive utilization tracking:

- Create an online platform where all EV incentives are managed, from application to approval. This portal should be user-friendly, allowing applicants to track their application status, receive updates, and submit necessary documentation. Also, ensure that dealerships have access to the platform to assist customers directly during the purchasing process. This would allow for real-time data entry and tracking of incentive usage.
- Collect comprehensive data on incentive applicants, including demographic information, income levels, geographic location, and the type of EV purchased. This will help identify

trends and disparities in incentive utilization. Also, implement periodic surveys for applicants to gather feedback on their experience with the incentive programs. This can provide insights into potential barriers and areas for improvement.

- Publish regular reports that detail the utilization of incentives, highlighting key metrics such as the number of incentives disbursed, geographical distribution, and demographic breakdown of recipients. Moreover, development of dashboards that allow policymakers and the public to monitor incentive utilization in real time can be useful. These dashboards can display key performance indicators (KPIs) like application processing times, disbursement rates, and geographic equity.

5.5 Key Lessons from California

To address the identified shortcomings and gaps in Nova Scotia's policies, following are the most useful strategies that can be learned from California's successful EV adoption framework:

5.5.1 Robust Policy Implementation

A robust policy framework is crucial for accelerating the transition to electric vehicles, as evidenced by California's success. The following points highlight the key elements of California's performance in this indicator, offering insights that could guide Nova Scotia in strengthening its own policy implementation efforts:

Stringent Regulations and Incentives: California's strict emissions regulations and generous financial incentives have been pivotal in driving EV adoption. Nova Scotia can benefit from enhancing financial incentives for both consumers and businesses.

Penalties and Enforcement Actions: Effective enforcement of EV-related policies in California ensures compliance and progress. Nova Scotia should develop clear penalties and robust enforcement mechanisms to ensure adherence to EV policies. These should address non-compliance with ZEV mandates, misuse of financial incentives, improper installation and maintenance of charging infrastructure, and violations of grid management policies.

Public Awareness Campaigns: California's extensive public awareness campaigns have significantly boosted consumer knowledge and acceptance of EVs. Nova Scotia needs to invest more in large-scale public awareness and education initiatives like Next Ride to make sure all the misconceptions of EVs are addressed.

5.5.2 Advanced Infrastructure Development

Advanced infrastructure development plays a critical role in supporting the widespread adoption of electric vehicles, as demonstrated by California's comprehensive efforts. The following points highlight California's performance in this indicator, offering strategies that Nova Scotia can leverage to enhance its own EV infrastructure and grid readiness:

Comprehensive Charging Network: California's extensive network of residential and public charging stations makes EV ownership convenient. Nova Scotia should prioritize expanding its charging infrastructure, focusing on both urban and rural areas to ensure maximum public accessibility.

Load Management and Grid Readiness: Effective load management programs in California help in managing the additional load from EVs on the grid. Through TOU rates, demand response programs, smart charging infrastructure, and utility-scale battery storage, the state effectively manages the additional load from EVs. These initiatives provide valuable insights and models that other regions, including Nova Scotia, can adopt to support their own EV infrastructure and grid management efforts. Nova Scotia should

develop and implement advanced load management strategies and ensure the grid is prepared for increased EV penetration.

Reliability and Customer Satisfaction: Monitoring the downtime of charging stations and customer satisfaction in California allows for continuous improvement. While the responsibility for charger maintenance lies with the owning companies, the provincial government in Nova Scotia can establish and enforce standards to ensure reliability and customer satisfaction. By setting clear performance metrics, providing incentives for high performance, and applying penalties for non-compliance, Nova Scotia can ensure a dependable and user-friendly EV charging experience, like the successful model in California. This approach will help build the necessary infrastructure and confidence among consumers to support broader EV adoption.

5.5.3 Effective Market Penetration Strategies

Effective market penetration strategies are essential for driving widespread electric vehicle adoption, as exemplified by California's comprehensive approach. The following points highlight California's performance in this indicator, providing insights that Nova Scotia can apply to enhance its own EV market penetration efforts.

Public vs. Private Charger Distribution: California's balanced approach to public and private charger distribution has been key to its success. Nova Scotia should aim for an equitable distribution of chargers, ensuring that both public and private charging needs are met. As of the latest data, Nova Scotia has only 35 DC fast charging stations across the province with 104 charging ports (Jarrat, NS Energy Operator, 2024). Efforts are underway to expand this network significantly, with initiatives such as the installation of up to 250 new Level 2 EV chargers funded by Natural Resources Canada (NRCAN, 2022).To improve overall EV adoption in the province, Nova Scotia should aim for a balanced distribution of both public and private chargers, following the successful example set by California.

Consumer Awareness and Acceptance: High levels of consumer awareness in California are a result of comprehensive education and marketing strategies. Nova Scotia needs to focus on increasing public understanding and acceptance of EVs through targeted marketing campaigns and educational programs.

Incentive Utilization: Detailed tracking of incentive utilization in California ensures that financial incentives are effectively reaching intended recipients. Nova Scotia should improve its tracking and reporting of incentive programs to ensure they are maximizing their impact.

5.5.4 Equity Consideration

Equity consideration is a vital aspect of California's electric vehicle strategy, ensuring that all communities benefit from the transition to clean transportation. The following points highlight California's performance in this indicator, offering actionable insights for Nova Scotia to enhance its approach to equitable EV adoption:

Targeted Subsidy Distribution: California's targeted approach to subsidy distribution ensures that benefits reach underserved communities. Nova Scotia should adopt similar strategies to ensure equitable access to subsidies across all demographics.

Community Engagement: Active community engagement initiatives in California foster greater acceptance and participation in the EV transition. Nova Scotia needs to enhance its community engagement efforts to build trust and support for EV adoption.

Workforce Diversity and Local Business Support: Promoting diversity in the EV workforce and supporting small and local businesses in California helps create inclusive economic opportunities. Nova Scotia should implement programs that encourage workforce diversity and provide support to local enterprises involved in the EV ecosystem.

These are the key lessons from California's EV transition journey and the strategies adopted by the state. Implementation of these strategies can help Nova Scotia to significantly improve its EV adoption rates, infrastructure development, and ensure a more equitable transition toward electric mobility.

5.6 Chapter Summary

The comparison between Nova Scotia and California's approach to EV adoption has highlighted areas where Nova Scotia is lagging in policy implementation, infrastructure development, market penetration, and equity considerations. California's success in EV adoption is due to its robust policy frameworks, significant infrastructure investments, aggressive market penetration strategies, and a strong focus on equity.

To increase EV sales in the province, Nova Scotia needs comprehensive policy support that includes financial incentives and regulatory measures. Infrastructure plays a critical role in facilitating the transition, so there is a need for strategic investments to ensure accessible, reliable, and equitable charging options across all regions. Market penetration strategies in California, driven by a combination of incentives, availability of diverse EV models, and public awareness campaigns, illustrate the multifaceted approach required to stimulate consumer demand. Furthermore, the focus on equity considerations in California offers a blueprint for ensuring that the benefits of the EV transition are shared across all demographics, addressing socio-economic and geographical disparities.

Nova Scotia can enhance its EV landscape by creating an enabling environment for EV adoption, investing in essential infrastructure, fostering market growth, and ensuring an equitable transition for all Nova Scotians. The success of these efforts will depend on the commitment of stakeholders across sectors, including government, industry, communities, and consumers, to embrace and drive forward the changes required.

6. Concluding Remarks

This thesis aimed to explore the multifaceted dimensions of electric vehicle (EV) adoption with a focus on energy security and equity considerations. The research investigated how various policies and infrastructure developments influence EV adoption and how these elements can be optimized to ensure an inclusive and equitable transition.

6.1 Objectives and How They Were Met

This section revisits the objectives of the thesis and explains how each objective is met with the help of this research.

6.1.1 Establishment of a Comprehensive Indicator Framework

The primary objective was to create a comprehensive set of indicators covering EV policy implementation, infrastructure readiness, market penetration, and inclusiveness and equity. This framework was developed through an extensive review of best practices in California. Due to stringent emissions standards and progressive policies that have driven ZEV adoption, comprehensive incentives, well organized and well-spread EV infrastructure, California was selected as a benchmark jurisdiction. By benchmarking against their policies, the research established a set of indicators that can be applied to various jurisdictions and can help them improve their EV adoption. Although, different jurisdictions will have different sizes, populations, and economic bases but EV markets that are in the developing phase right now, to improve their EV adoption they would have to set the developed jurisdictions' EV market as their benchmark and build their standards accordingly.

6.1.2 Assessment of Policy Implementation and Effectiveness

The second objective was to assess the effectiveness of policies promoting EV adoption. The research evaluated policy frameworks, incentives, and regulatory measures in Nova Scotia and compared them with those in California. The analysis identified key areas where Nova Scotia's policies could be strengthened, such as through enhanced enforcement actions, expanded public awareness campaigns, and integrating EV education initiatives.

6.1.3 Evaluation of Infrastructure Development

The third objective was to evaluate the development and availability of EV charging infrastructure. The research analyzed the density, distribution, and public accessibility of charging stations in Nova Scotia, emphasizing the need for equitable infrastructure development. It highlighted the importance of addressing urban-rural disparities to support a balanced transition. Nova Scotia has made significant progress with multiple investments in expanding its EV charging infrastructure. The investments made indicate a strong commitment to enhancing the availability of charging stations across the province. Moreover, the distribution of charging stations is strategically planned to cover key routes and locations, including public areas, highways, and commercial sites. However, there are still notable gaps, particularly in rural and underserved areas. Municipalities like East Hants, Cape Breton, and Chester have high resident-per-charger ratios, indicating a need for more chargers to support these regions considering that fact that Cape Breton is a tourist area with a lot of outsiders visiting throughout the year. The province's goal to achieve 80% renewable electricity by 2030 significantly supports sustainable EV charging. The reliance on renewable sources such as wind and hydroelectric power aligns with Nova Scotia's climate goals and enhances the environmental benefits of EVs.

There is a noticeable disparity in the availability of charging infrastructure between urban centers and rural areas. Halifax, for example, has over 100 charging stations, making it a central hub for EV infrastructure. In contrast, counties like Shelburne, Digby, Guysborough, and Victoria have negligible charging stations, limiting public accessibility for EV users in these areas. Addressing these disparities is essential for ensuring that all regions can participate in the transition to electric vehicles. Continued investment and strategic placement of charging stations in rural and underserved areas are necessary to support equitable EV adoption across the province.

6.1.4 Analysis of Market Penetration

The fourth objective was to assess market penetration factors such as sales trends and market share. The comparative analysis revealed that consumer awareness and incentive utilization play significant roles in higher adoption rates. The key findings were that EVs constitute about 4.3% of new vehicle sales in Nova Scotia, significantly trailing behind leading provinces like Ontario, British Columbia, and Quebec. Moreover, Halifax has the highest EV market share and infrastructure support, but other counties lag in both EV sales and charging infrastructure. Also, counties with better median household incomes generally see higher EV sales. It was also found through EV rebate registration data that where vehicles are used, not just where they are purchased.

6.1.5 Inclusivity and Equity Considerations

The fifth objective focused on assessing the equity outcomes of EV policies and infrastructure. The research examined whether current policies disproportionately disadvantaged marginalized communities. This assessment was based on several key considerations including economic inclusivity, infrastructure distribution and work force development. Economic inclusivity refers to affordability of EVs, availability if used EVs and incentive distribution. Infrastructure distribution refers to urban vs rural access and inclusivity in infrastructure. And workforce development refers to training programs and diversity in workforce. The research underscores the importance of addressing equity considerations in EV policies and infrastructure development. By focusing on inclusive policies that support diverse groups and promote community engagement, Nova Scotia can ensure a fair and equitable transition to electric vehicles. This approach aligns with broader goals of energy security and equity, ensuring that all communities benefit from the shift to sustainable transportation.

6.1.6 Comparative Analysis across Jurisdictions

The final objective was to perform a comparative analysis between jurisdictions. The research provided insights into best practices and areas for improvement by comparing Nova Scotia's efforts with those of California. This comparison highlighted successful strategies that Nova Scotia could adopt to enhance its EV adoption efforts like a ZEV mandate, robust incentive programs, comprehensive charging infrastructure, workforce development and training, community engagement, and education. The research highlighted that adopting a ZEV mandate could ensure a consistent supply of EVs in the market, driving adoption rates similar to California. Moreover, increasing the value of rebates and tax credits, particularly for low-to-moderate-income households, could make EVs more affordable and accessible. Investing in a comprehensive and equitable network of charging stations, especially in rural and disadvantaged communities, would promote broader adoption. Also, implementing extensive training programs for EV maintenance and service and promoting workforce diversity could prepare Nova Scotia for the growing EV market.

6.2 Contributions and Findings

The thesis made several significant contributions to the understanding of EV adoption:

- Developed a comprehensive indicator framework adaptable to various jurisdictions. The thesis introduced a framework that includes indicators such as charging infrastructure density, policy effectiveness, consumer incentives, and market penetration rates. This framework can be adapted to evaluate EV adoption in different regions by adjusting the weights and metrics based on local conditions and priorities. This adaptability is crucial, as seen in how California's policies might focus more on urban congestion relief and air quality improvements, while a region like Nova Scotia may prioritize rural public accessibility and energy security.
- Provided a detailed assessment of policy effectiveness in promoting EV adoption. The thesis assessed specific policies, such as California's ZEV mandates to determine their impact on EV market penetration and consumer behavior. In California, ZEV mandates have led to a significant increase in EV availability and sales, showing a direct correlation between stringent policies and market outcomes.
- Highlighted the importance of equitable infrastructure development and addressed urban-rural disparities. By analyzing the distribution of charging stations in Nova Scotia, the thesis underscored the need for more equitable infrastructure development to support both urban and rural areas. The disparity in charging infrastructure between urban centers like Halifax and rural areas in Nova Scotia reflects a significant barrier to EV adoption in less densely populated regions.
- Emphasized the role of consumer awareness and incentives in market penetration. The thesis demonstrated how consumer awareness campaigns and financial incentives can drive EV adoption by reducing perceived risks and financial barriers. Public awareness programs in California, combined with rebates and tax credits, have significantly boosted consumer interest and adoption rates. Nova Scotia can benefit from similar initiatives to improve market penetration and public acceptance of EVs.
- Stressed the need for inclusivity and equity in EV policies to avoid disadvantaging marginalized communities. The thesis argued for inclusive policies that consider the needs of marginalized communities, ensuring that the benefits of EV adoption are accessible to all. California's focus on low-income communities through programs like the Clean Vehicle Rebate Project (CVRP) ensures that disadvantaged groups are not left behind in the transition to electric mobility. Similar strategies can be adapted in Nova Scotia to ensure equitable benefits from EV policies.
- Offered comparative insights from leading jurisdictions to guide Nova Scotia's policy improvements. The thesis drew on successful strategies from leading EV markets like California to provide actionable recommendations for Nova Scotia. By comparing the comprehensive EV adoption strategies in these jurisdictions, the thesis provided a roadmap for Nova Scotia to enhance its policies. This includes adopting ZEV mandates, expanding public charging infrastructure, and providing consumer incentives.

6.3 Limitations of Work

While this thesis provides a comprehensive analysis of electric vehicle (EV) adoption with a focus on energy security and equity considerations, there are several limitations that must be acknowledged.

6.3.1 Data Availability and Quality

One of the primary limitations of this research is the availability and quality of data. In some instances, data on EV adoption, charging infrastructure, and policy impacts were either limited or not up-to-date. This limitation particularly affected the assessment of infrastructure development in rural areas of Nova Scotia, where detailed data on charging station utilization and public vs. private infrastructure were

scarce. Additionally, gaps in data regarding the long-term effects of incentives on consumer behavior and the regional differences in EV adoption hindered a more detailed analysis.

6.3.2 Scope of Comparative Analysis

The comparative analysis between Nova Scotia and California was another area with limitations. While California serves as a useful benchmark due to its advanced EV policies and infrastructure, differences in geographic size, population density, economic conditions, and political frameworks limit the direct applicability of California's strategies to Nova Scotia. The research, therefore, might oversimplify the complexities involved in translating best practices from a large, economically diverse state like California to a smaller, less densely populated province like Nova Scotia.

6.3.3 Generalizability of Findings

The findings and recommendations of this thesis are largely focused on Nova Scotia and may not be entirely generalizable to other regions with different socioeconomic, geographic, and policy environments. The specific challenges and opportunities faced by Nova Scotia in terms of EV adoption might differ significantly from those in other provinces or countries, limiting the broader applicability of the research conclusions. The indicators of the framework might need to be adjusted according to the jurisdiction it is being applied on.

6.3.4 Focus on Existing Technologies and Policies

The thesis primarily focuses on current technologies and policy frameworks, which means that emerging technologies and future policy developments were not thoroughly explored. For instance, while vehicle-to-grid (V2G) systems and advanced battery technologies were mentioned as areas for future work, they were not deeply analyzed within the current scope. This focus on existing frameworks may limit the thesis's ability to anticipate future trends and technological breakthroughs that could significantly alter the EV adoption landscape.

6.3.5 Time Constraints

Finally, the research was conducted within a limited timeframe, which constrained the depth of certain analyses. For instance, a more extended study period could have allowed for longitudinal data collection and a more thorough exploration of how policies evolve and impact EV adoption over time. Additionally, time constraints limited the ability to conduct more extensive fieldwork, such as surveys or interviews with various stakeholders across different regions of Nova Scotia.

In summary, while this thesis makes significant contributions to understanding EV adoption in Nova Scotia, these limitations highlight the need for ongoing research and data collection to address the gaps and enhance the robustness of future studies.

6.4 Future Work

While this thesis has provided a comprehensive analysis of EV adoption, there are areas for future research:

Longitudinal Studies: Conduct longitudinal studies to track the long-term impacts of EV policies and infrastructure developments on adoption rates and equity outcomes. Longitudinal studies are crucial for understanding the long-term impacts of EV policies and infrastructure developments on adoption rates and equity outcomes. By tracking changes over time, these studies can provide insights into the effectiveness of current policies and highlight areas needing adjustment. Longitudinal studies can reveal how policies influence consumer behavior and market dynamics over extended periods. For instance, California's long-term data on ZEV mandates shows how sustained policy efforts lead to significant increases in EV adoption and market transformation. Understanding how infrastructure developments

impact different socioeconomic groups over time is essential for ensuring equitable access to EV benefits. Continuous tracking can help identify whether disparities are being addressed or if new gaps are emerging.

Technological Advancements: Investigating the implications of emerging technologies, such as vehicle-to-grid (V2G) systems and advanced battery technologies, is essential for assessing their potential impacts on energy security and grid readiness. These technologies can significantly influence the feasibility and sustainability of widespread EV adoption. V2G systems allow EVs to feed electricity back into the grid, enhancing energy security by providing additional storage and supply flexibility. Studies on V2G technology demonstrate its potential to stabilize the grid and support renewable energy integration. Advanced battery technologies promise higher energy densities, faster charging times, and longer lifespans, all of which are critical for consumer acceptance and grid management. Research into these technologies can help predict future infrastructure needs and inform investment decisions.

Behavioral Studies: Understanding consumer behavior and preferences regarding EV adoption, especially among diverse socioeconomic groups, is key to identifying barriers and motivators. Behavioral studies can inform more effective policy and marketing strategies tailored to different demographics. Behavioral research can uncover specific barriers faced by different groups, such as concerns about range anxiety, charging infrastructure, and upfront costs. Identifying what motivates different consumer groups to adopt EVs, whether environmental concerns, cost savings, or technological appeal, can help design targeted incentives and promotional campaigns. For instance, studies have shown that financial incentives are particularly effective among low- to middle-income households.

6.5 Recommendations for Policymakers in Nova Scotia

Based on the findings of this thesis, the following recommendations are proposed for Nova Scotia to enhance its EV adoption efforts:

Strengthen Policy Measures: Develop clear and enforceable regulations for EV policies. This includes setting penalties for non-compliance with ZEV mandates, such as fines for manufacturers and dealerships that do not meet EV sales targets. For example, California's ZEV mandate includes penalties for automakers that fail to sell a certain percentage of ZEVs, encouraging compliance and fostering a robust EV market.

Expand Public Awareness Campaigns: Launch comprehensive public awareness campaigns that highlight the benefits of EVs, available incentives, and the environmental impact of switching to electric vehicles. Utilize multiple platforms such as social media, public service announcements, and community events. For instance, California's Drive Clean campaign effectively raises awareness about the benefits of EVs and available rebates, leading to higher adoption rates.

Enhance Infrastructure Development: Focus on expanding the charging infrastructure, particularly in rural and underserved areas. Provide grants and subsidies to encourage the installation of charging stations in these regions.

Support Local Businesses: Provide incentives and support for small and local businesses to participate in the EV market. Offer financial incentives, tax breaks, and grants to local businesses to support their entry into the EV market. This can include subsidies for installing charging stations and switching to electric fleets. Programs like California's Clean Vehicle Rebate Project (CVRP) support local businesses in adopting EVs by providing rebates and incentives.

Foster Community Engagement: Engage with communities to understand their specific needs and address barriers to EV adoption. Conduct surveys, focus groups, and town hall meetings to understand the specific needs and concerns of different communities regarding EV adoption. Use this feedback to shape policies and programs. For example, The City of Portland's EV strategy includes community engagement initiatives to ensure that the needs of all residents, including marginalized communities, are addressed.

Monitor and Adjust Incentives: Establish a system to regularly monitor the utilization rates of EV incentives and adjust them based on effectiveness. This can include increasing rebate amounts, expanding eligibility criteria, or introducing new incentives for different types of EVs. For example, Quebec continuously monitors its EV incentive program and adjusts rebate amounts based on market conditions and adoption rates to ensure maximum impact.

Promote Diversity in the EV Workforce: Encourage diversity within the EV industry to ensure a broad range of perspectives and innovations. Create programs and partnerships with educational institutions to promote diversity in the EV industry. This can include scholarships, internships, and training programs targeted at underrepresented groups.

In conclusion, this thesis has achieved its objectives by providing a comprehensive framework for evaluating EV adoption efforts. The insights and recommendations derived from this research offer valuable guidance for Nova Scotia to enhance its EV policies, infrastructure, and market strategies. By addressing identified gaps and adopting best practices from leading jurisdictions, Nova Scotia can improve its EV adoption rates and contribute significantly to meeting both provincial and federal EV sales targets, ensuring a sustainable and equitable transition to electric mobility.

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