North Carolina Transportation Electrification Roadmap

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This Roadmap is meant to guide the development of a range of high impact policies to drive forward electric vehicle adoption across North Carolina. First, it explores the significant benefits to the State of adopting a collection of “core policies” that set standards for light-, medium-, and heavy-duty vehicle electrification. This report contains modeling results to determine the potential costs and benefits created from increased levels of light-duty (LDV) and medium- and heavy-duty vehicle (M/HDV) electrification resulting from policy implementation within North Carolina. A complete report on the modeling analysis is included in the appendix. The core policies described in the section below offer a clear pathway to achieve North Carolina’s ambitious electric vehicle goals and sector GHG emission reductions all while providing significant societal benefits that will positively impact North Carolinians across the State. The analysis included in this report finds that those benefits could reach $150 billion by 2050.

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GLOSSARY

- ACC II: California's Advanced Clean Cars II rulemaking
- ACT: California's Advanced Clean Trucks rule
- AFV: Alternative fuel Vehicle
- BEV: Battery electric vehicle
- CATS: Charlotte Area Transit System
- CNG: Compressed natural gas
- CO_2: Carbon dioxide
- DCFC: Direct Current Fast Charger
- DEQ: Department of Environmental Quality
- DOA: Department of Administration
- DOT: Department of Transportation
- EPA: Environmental Protection Agency
- EV: electric vehicle
- EVSE: Electric vehicle supply equipment
- FCEV: Fuel cell electric vehicle
- GHG: Greenhouse gas
- ICE: Internal combustion engine
- IIJA: Infrastructure Investment and Jobs Act
- IOU: Investor-owned utility
- L1: Level 1 electric vehicle charger
- L2: Level 2 electric vehicle charger
- LDV: Light-duty vehicle
- M/HDV: Medium- and heavy-duty vehicle
- MBUF: Mileage-based user fees
- MFM: Motor fleet management
- MHD ZEV MOU: Medium- and Heavy-duty Zero-Emission Vehicle Memorandum of Understanding
- MT: Metric tons
- NASEO: National Association of State Energy Officials
- NCCN: North Carolina Conservation Network
- NCSEA: North Carolina Sustainable Energy Association
- NEHC: National Electric Highway Coalition
- NO_X Omnibus: California's Nitrogen Oxide Omnibus rule
- NO_X: Nitrogen oxide
- OEM: Original equipment manufacturer
- PAYS: Pay-As-You-Save model
- PHEV: Plug-in Hybrid Electric Vehicle
- PM: Particulate matter
- SACE: Southern Alliance for Clean Energy
- STSFA: Surface Transportation System Funding Alternative
- T-ESCo: Transportation Energy Service Companies
- TNC: Transportation network company
- TOU: Time-of-Use
- V2G: Vehicle-to-Grid
- VMT: Vehicle miles traveled
- ZEV: Zero-emission vehicle

1. EXECUTIVE SUMMARY

Transportation sector emissions are the largest source of greenhouse gas emissions (GHG) within the state of North Carolina as well as a major source of fine particulate matter ($PM_{2.5}$, identified as PM going forward) and nitrogen oxides (NOx).[1] Recognizing that reducing transportation sector emissions is critical to achieving State emission reduction goals and improving human and environmental health, the State has taken steps over the last several years to combat vehicle emissions. To date, many of these actions have focused on reducing emissions from the transportation sector by increasing the number of zero emission vehicles (ZEVs) on the road given the expansion of available ZEV models, decline in vehicle costs, and, importantly, reductions in local air pollutants associated with a vehicle that produces zero tailpipe emissions. Electric vehicles can significantly reduce PM as well as NOx emissions within communities throughout the State especially for those that are disproportionately burdened by vehicle pollutants—particularly when investments are targeted in these communities and policies are designed with equity at the forefront. These strategies coupled with the State's already aggressive power sector emissions reduction goals can enable even greater emissions reductions for electrified vehicles furthering their environmental and societal benefits.[2,*] Not only does vehicle electrification reduce climate warming emissions but given current volatile gas prices and ongoing geopolitical concerns, it can stabilize consumer vehicle operating costs across the state of North Carolina.

Most recently, Governor Cooper signed Executive Order No. 246 (EO 246), *North Carolina's Transformation to a Clean, Equitable Economy*, which set several new targets for the State including actions directed at the transportation sector.[3] EO 246 set a new ZEV registered vehicle target of at least 1,250,000 vehicles by 2030 and created a new ZEV sales target that requires at least 50 percent of in-state sales of new vehicles to be zero emission by 2030. EO 246 also directs the North Carolina Department of Transportation (DOT), Department of Environmental Quality (DEQ), and other agencies to develop a North Carolina Clean Transportation Plan for the Climate Council to submit to the Governor by April 2023. In addition, EO 246 directs State agencies to center climate action around environmental justice, equity, and affordability for all North Carolinians. To reach these emission reductions and ZEV targets, the State will need to both adopt standards that send a market signal ensuring electric vehicles come into the State and also develop a set of high impact policies that increase the sale of electric vehicles and ensure emissions reductions for communities across North Carolina, including those that are disproportionately burdened by vehicle emissions.

This report is meant to guide the development of a range of high impact policies to drive forward electric vehicle adoption across the State. First, it explores the significant benefits to the State of adopting a collection of "core policies" that set standards for light-, medium-, and heavy-duty vehicle electrification. These policies include the adoption of the Advanced Clean Cars II (ACCII), Advanced Clean Trucks (ACT) and the Nitrogen Oxides (NOx) Omnibus Rules. This report contains modeling results to determine the potential costs and benefits created from increased levels of light-duty vehicle (LDV) and medium- and heavy-duty vehicle (M/HDV) electrification resulting from policy implementation within North Carolina. A complete report on the modeling analysis is included in the appendix.

The core policies described in the section below offer a clear pathway to achieve North Carolina's ambitious electric vehicle goals and sector GHG emission reductions all while providing significant societal benefits that will positively impact North Carolinians across the State. The analysis included in this report finds that those cumulative benefits could reach $150 billion by 2050, including:

- Approximately $92 billion in net savings from annual incremental EV purchase costs for both LDVs and M/HDVs, annual incremental charging infrastructure costs, annual incremental low

[*] North Carolina's HB951 Legislation requires a 70 percent reduction in emissions from the electric grid from 2005 levels by 2030.

NOx (LNOx) ICE vehicle purchase costs, savings from vehicle maintenance costs, and annual charging infrastructure maintenance costs;

- Almost $52 billion in the monetized value of GHG, NOx, and PM reductions from improving health effects, including over 1,000 cases in reduced mortality, almost 680 cases of reduced hospitalization, 380 cases of reduced asthma-related emergency room visits, and 640,000 reduced cases of diminished activity or lost work days; and
- Nearly $7 billion in utility net revenue.

However, the State, like many across the country, faces several barriers to the rapid electrification envisioned by these policies. Often for these core policies to be implemented with the lowest cost and impact on consumers they must be supported by a broad range of state and local measures that proactively reduce implementation barriers. Therefore, the second part of this report is a Roadmap that highlights five categories of policies that will be critical to meeting the State's goals strategically, cost effectively, and equitably. These categories include infrastructure development, financing, education and outreach, and state leadership opportunities.

These complementary policies, when combined with the modeled core policies, set the State on a pathway to ensure vehicle electrification is not only supported and North Carolina's ambitious targets can be met but, the societal benefits of vehicle electrification can be maximized and distributed to communities across the State, particularly to those that are disproportionately burdened by climate change and transportation pollutants. These benefits—including improved air quality, reductions in climate warming GHG emissions, utility customer savings, and vehicle owner savings—will put the State on a pathway that centers climate action around environmental justice, equity, and affordability for all North Carolinians. Taken together, the actions outlined within this Roadmap will help the State meet its ambitious targets and secure significant benefits.

The following table highlights the key policy recommendations from this report and analysis.

Table 1. Key Core and Complementary Policy Recommendations

Policy Roadmap	Key Recommendations
Core Policies	
Adopt electric vehicle standards that establish a meaningful EV market within the state of North Carolina.	Adopt a set of LD regulations that go beyond the current goals set by the state of North Carolina and the Biden Administration including, pending approval by the state of California, the Advanced Clean Cars II Rule
	Adopt a series of M/HD regulations including the Advanced Clean Trucks, NOx Omnibus, and Advanced Clean Fleets Rules.
Complementary Policies	
Infrastructure Development	
Develop infrastructure planning and incentives that promote equitably distributed charging infrastructure.	Develop a plan for accessing Federal funding from the passage of the Infrastructure Investment and Jobs Act (IIJA).
	Develop charging rebate program and tier residential charger rebates based on income eligibility.
	Establish long term infrastructure build-out plans.

	Develop effective curbside charging and parking strategies.
Collaborate at the state and regional level to develop infrastructure and partner with key stakeholders to ensure that charging infrastructure is developed strategically and cost effectively.	State, regional, and local governments should collaborate to invest in developing regional charging networks to ensure that both rural and urban communities have access to the infrastructure needed to support electrification.
	State policy makers should focus on increasing awareness around the benefits of electric vehicle ownership.
	Partner with utilities to offer technical expertise on charging infrastructure upgrades, support charging stations, and can provide, pending regulatory approval, several different types of programs designed to incentivize the deployment of chargers within both public and private spaces.
	Work with EVSE Providers to ensure reliable and consistent charging experience.
	Ensure sustained engagement of leaders in disproportionately impacted communities at every stage of the planning process.
Vehicle Financing	
Structure grant funding approaches to support the needs of communities across the state of North Carolina.	Develop policy objectives to help better align grant programs with zero emission transition needs.
	Allocate funding across the M/HDV sector to address unique sector needs.
	Introduce flexibility to finance vehicles and infrastructure including adopting more innovative financing solutions.
	Target public funds towards sectors, populations, and locations that are not likely to be served by the private sector in the near-term.
Develop incentive programs that focus on increasing electric vehicle accessibility.	Consider alternative fee structures that can be applied across vehicle types.
	Adopt a rebate program that includes rebates that are offered at or after the point of sale to accommodate varying consumer needs across LD and M/HD vehicle sectors.
Explore additional innovative financing solutions (e.g., leasing models; green back; vehicle to grid; pay as you save; transport energy service company)	Encourage and implement public-private partnerships and collaborations.
	Support the development of pilot programming where appropriate.
	Encourage and implement public-private partnerships and collaborations.
	Enable utilities to pursue changes to their rates to promote managed charging throughout their service territories.
	Provide incentives for used electric vehicles.
	Increase and incentivize public and private fleet turnover.

Support the development of a used electric vehicle market	Develop marketing and outreach plans for used vehicles.
Education and Outreach	
Increase workforce development.	Develop statewide workforce ZEV training program to increase the number of ZEV technicians and electricians within the state.
Develop state programming to increase public awareness of EVs.	Establish an EV infrastructure toolkit that: 1) identifies charger options, 2) provides utility contacts for the installation of supporting electrical equipment, 3) recommends qualified electricians, 4) identifies rebates, and 5) details local permitting requirements.
State Leadership	
Support and develop the infrastructure to foster low-emission travel.	Encourage low-emission travel by encouraging state employees to support local transit systems by providing free or reduced cost passes.
	Work with state, regional and local governments to develop Local and Regional Charging Networks.
Lead by example in fleet electrification and EV job creation.	Electrify transit and public service fleets with state and local government.
	Create job opportunities by incentivizing electric vehicle manufacturing in communities.

2. BENEFITS OF TRANSPORTATION ELECTRIFICATION TO NORTH CAROLINIANS

ERM conducted a study to estimate the impacts of EVs on fuel use and emissions, air quality and public health, utility customer bills, and EV owners. The study also included an economic and gap analysis on EV charging infrastructure. All components are monetized to understand the net societal benefits of EV adoption in North Carolina.

A total of three scenarios were modeled as part of this analysis. Each scenario included "core policies" for both the LDV and M/HDV market. The LDV sector modeling evaluated what different EV penetration scenarios could have on North Carolina, such as high impact policies that are currently being proposed or considered by other states (e.g., California's Advanced Clean Cars II rulemaking [ACC II])[*] or that could be implemented at the Federal level (e.g., the Biden Administration's 2030 EV sales targets).[†] The M/HDV sector modeling considered both EV adoption policies (e.g., California's Advanced Clean Trucks

[*] Draft regulations of ACCII released in December 2021 would require vehicle manufacturers to sell increased levels of EVs starting in 2025 and reaching 100 percent sales by 2035

[†] The Biden Administration recently set an EV goal of achieving 50 percent of new passenger vehicles and light trucks sold in 2030 be zero emission vehicles.

Rule [ACT])[*] as well as increased NOx tailpipe emission stringency policies for internal combustion engine (ICE) vehicles (e.g., California's NOx Omnibus Rule [NOx Omnibus]).[†]

The three modeled scenarios are outlined below.

- The **"Medium Scenario"** adopted the Biden Administration's EV goal of achieving 50 percent of new passenger vehicles and light-duty trucks sold to be zero emission vehicles by 2030[4] and includes North Carolina fully adopting the ACT and NOx Omnibus rules.[‡]
- The **"High Scenario"** adopted the proposed ACC II regulation and included the full adoption of both the ACT and NOx Omnibus Rules. Additionally, the scenario increases the ACT program overtime resulting in 100 percent of all M/HDV sales being ZEV after 2040.
- A **"High (Clean Grid) Scenario"** used the same vehicle adoption trajectories as the High Scenario, but also includes a clean electric grid mix based on North Carolina's HB951 Legislation[§]

These three scenarios were compared to a "Baseline Scenario" that achieves Environmental Protection Agency's (EPA) emission standards and includes EV sales that increase very slightly, reaching approximately 21 percent of passenger car and light-duty truck sales.[**] Within the M/HDV sector, the Baseline Scenario assumes new commercial trucks sold in the State continue to meet existing EPA NOx emission standards and EV truck sales that increase only marginally, never reaching more than 1 percent of new vehicles sales each year.[††]

Total EV penetration by segment for each case are shown in Table 2 below.

Table 2. Percent In-Use Vehicles Electric by 2050

Case	% In Use Vehicles Electric in 2050	
	LDV	*M/HDV*
Baseline	13.6%	0.9%
Medium	66.2%	58.9%
High & High Clean	95.8%	95.4%

Key takeaways from this analysis include:

- **The High (Clean Grid) Scenario that includes the adoption of the ACCII, ACT, and the NOx Omnibus Rule, paired with significant emissions reductions from the power sector will have the greatest GHG emissions and vehicle pollutant reduction potential.** Each Scenario represents a reduction in carbon dioxide (CO_2) over the baseline. The High (Clean Grid) scenario that includes the adoption of the ACCII, ACT, and the NOx Omnibus Rule, and includes a clean

[*] The ACT Rule requires an increasing percentage of new trucks purchased in the State to be EVs beginning in the 2025 model year, the percentage of new vehicle that must be EV varies by vehicle type, but for all vehicle types that required EV percentage increases each model year between 2025 and 2035. By 2035, zero emission truck sales need to be 55 percent of Class 2b to 3 truck sales, 75 percent of Class 4 to 8 straight truck sales, and 40 percent of combination trucks.

[†] The NOx Omnibus regulation requires an additional 75 percent reduction in NOx emissions from engines in new gasoline and diesel trucks sold between model year 2025 and 2026, and a 90 percent reduction for trucks being sold beginning in the 2027 model year. Reductions are relative to current federal EPA new engine emission standards. This rule does not require additional PM reductions but includes anti-backsliding provisions to ensure that PM emissions do not increase compared with engines designed to meet current federal standards.

[‡] Since the completion of this analysis, Governor Cooper signed EO 246, *North Carolina's Transformation to a Clean Equitable Economy*, which created a new ZEV sales target in line with the Biden Administration's goals of at least 50 percent of in-state sales of new vehicles to be zero emission by 2030.

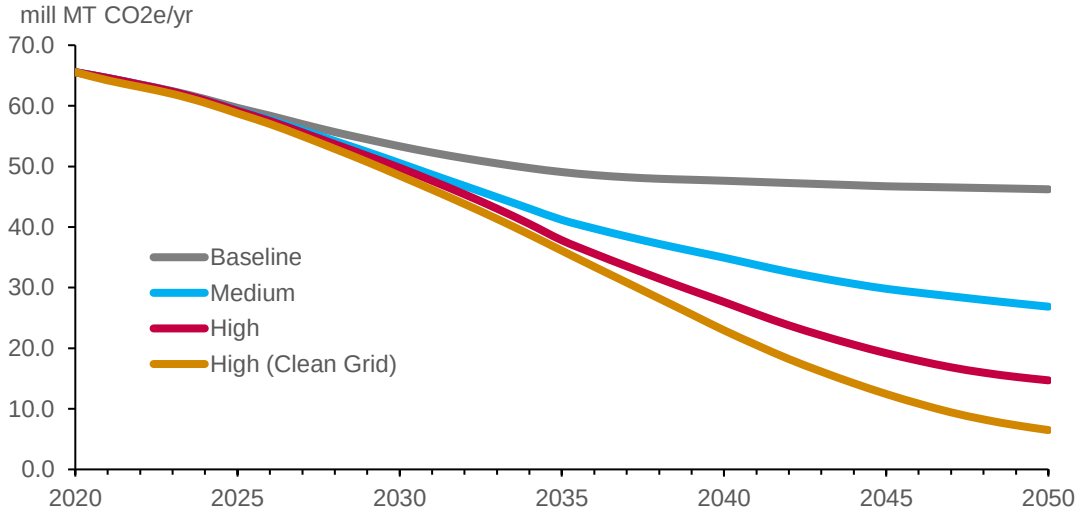
[§] North Carolina's HB951 Legislation requires a 70 percent reduction in emissions from the electric grid from 2005 levels by 2030

[**] The baseline EV sales assumptions are consistent with projection in the Energy Information Administration's Annual Energy Outlook 2021.

[††] The baseline EV sales assumptions are consistent with projection in the Energy Information Administration's Annual Energy Outlook 2021.

grid emissions reduction target will reduce emissions by 90 percent by 2050 compared to 2020 levels. The modeling also concluded that the cumulative monetized value of GHG emission reductions could reach over $39 billion by 2050 for the High (Clean Grid) Scenario**.** The High Scenario that includes the adoption of the ACCII, ACT, and the NOx Omnibus Rule, but excludes clean grid provisions will have the second highest emissions reduction potential decreasing emissions by 78 percent by 2050 compared to 2020 levels. The Medium Scenario, which adopted the Biden Administration's EV goal and includes North Carolina fully adopting the ACT and NOx Omnibus rules will result in a 59 percent emissions reduction potential in 2050 compared to 2020 levels. (See **Figure 1**).

Figure 1. Estimated On-Road Vehicle Related GHG Emissions



- **The High (Clean Grid) Scenario will have the greatest public health benefits to North Carolina, reducing both NOx and PM emissions, resulting in North Carolina residents breathing in fewer pollutants. This will have positive health impacts and can reduce premature mortality and result in fewer hospital admissions and emergency room visits for asthma, among other health benefits.** The High (Clean Grid) Scenario, emissions for NOx and PM are expected to fall 31 percent and 43 percent respectively by 2050 with cumulative reductions of 480,922 metric tons (MT) of NOx and 14,646 MT of PM, compared to the Baseline. The High Scenario will reduce emissions for NOx and PM, compared to the Baseline, by an estimated 19 percent and 29 percent, respectively, representing a cumulative reduction of 426,892 MT of NOx and 9,762 MT of PM by 2050. Finally, the Medium Scenario is estimated to decrease NOx by 2 percent and PM by 18 percent in 2050, this represents a cumulative reduction in emissions between 2020 to 2050 of 379,683 MT for NOx and 6,230 MT of PM. See **Figures 2 and 3 and Table 3** below.

Figure 2. Estimated on-Road Vehicle Related NOx Emissions

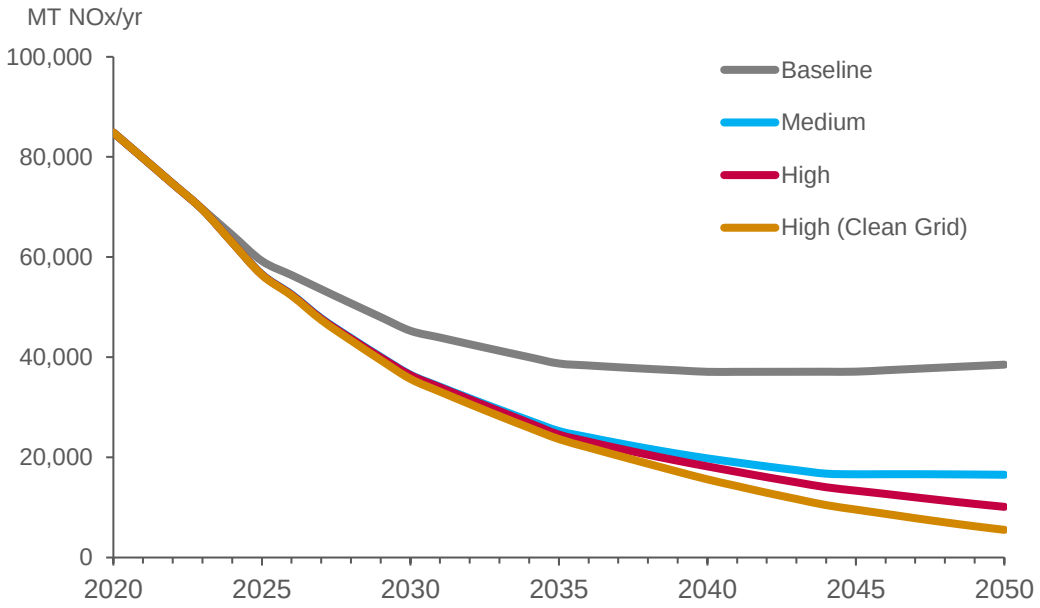


Figure 3. Estimated On-Road Vehicle Related PM Emissions

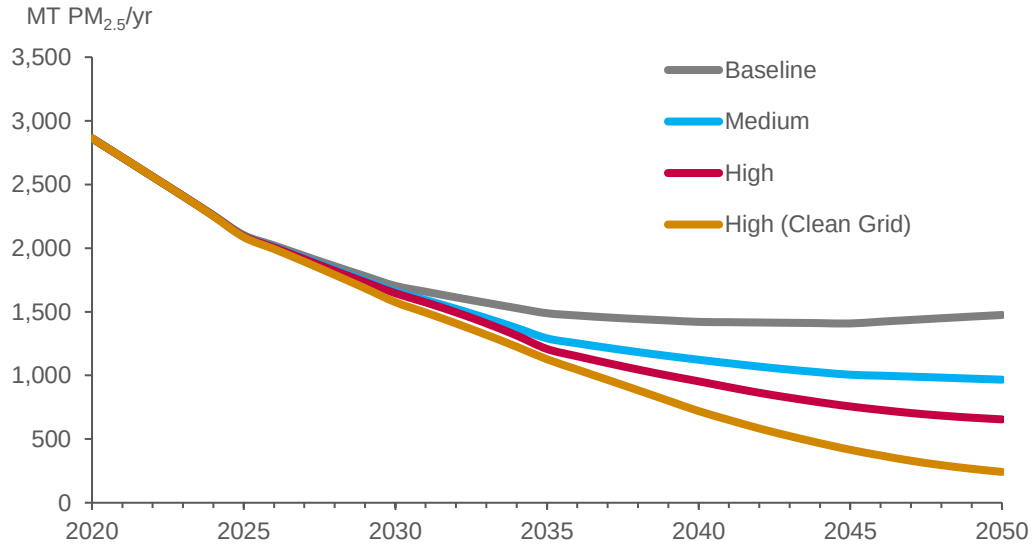


Table 3. Cumulative Estimated Reductions in Health Outcomes Under Modeled Scenarios

Policy Scenario*	Cum. Reduction (MT)		Cumulative Reduced Incidents				Monetized Value (2020$ bil)
	NOx	PM	Mortality	Hospital**	Asthma-Related Emer. Room	Restricted Activity Days***	
Medium	379,638	6,230	773	493	277	463,271	$9.0
High	426,892	9,762	1,007	640	359	603,369	$11.8
High (Clean Grid)	480,922	14,646	1,070	679	379	636,083	$12.5

** Compared to the Baseline Scenario*

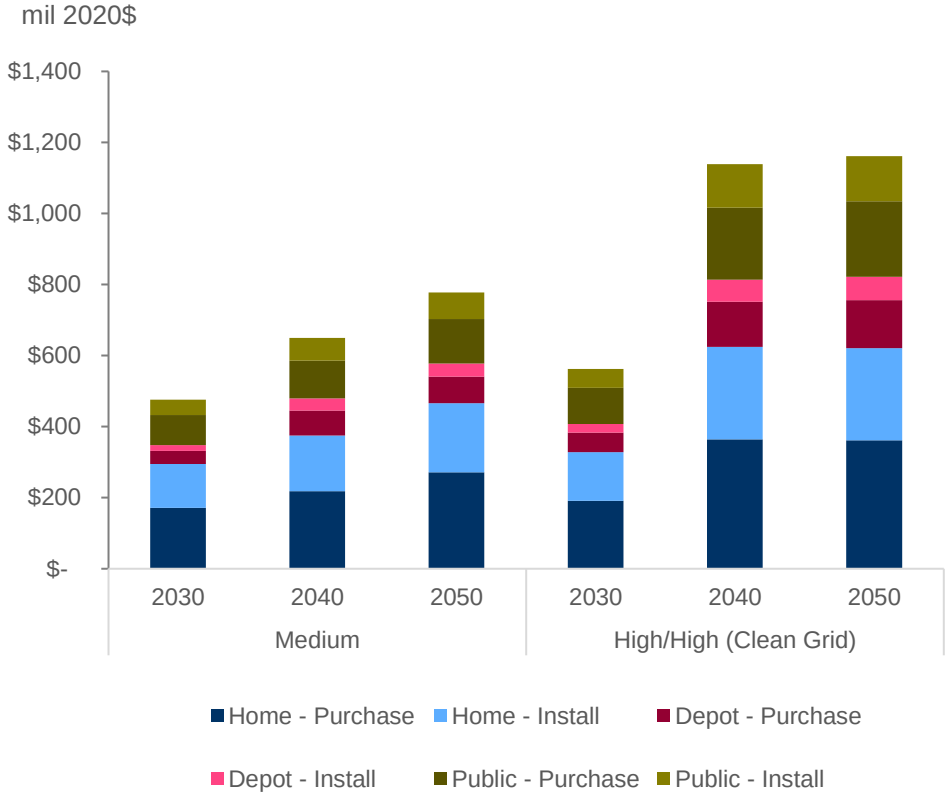
***Hospital visits include respiratory-related hospitalizations, asthma-related hospitalizations, hospitalizations related to chronic lung disease, and cardiovascular-related hospitalizations*

****Restricted activity days are days where activity is limited, but not severely restricted, for example missing work*

- **Investments in charging infrastructure are significant in all modeled scenarios**.[*] Key policy and funding can help support these high infrastructure costs. For the High and High (Clean Grid) Scenarios a little more than 9 million charge ports are needed by 2050, with investments reaching approximately $1.2 billion per year (2020$). Within the Medium Scenario almost 6 million charge ports are needed by 2050, with investments of approximately $780 million per year (2020$). **Figure 4** below shows the amount of investment needed to support the modeled EV penetration scenarios, broken out by type of charger (home, public, or depot) and the type of investment needed (purchase or install costs).

[*] It should be noted that the model assumes average investments made yearly, but some of these infrastructure investments may have to be frontloaded.

Figure 4. Annual Cost of EV Charging Infrastructure for Modeled Scenarios



- **Deploying transportation electrification policies can yield significant net societal benefits.** The analysis concluded that overall net societal benefits (including air quality benefits, climate benefits, utility customer savings, and EV owner savings by 2050) will yield annual benefits of $7.5 billion, $12.0 billion, and $12.8 billion for Scenarios Medium to High (Clean Grid), respectively. The cumulative benefits between 2021 and 2050 amount to $91 billion, $142 billion, and $150 billion for Scenarios Medium to High (Clean Grid), respectively. Additional complementary policies (outlined in the sections below) that increase EV adoption and funding for EV charging ports will be key to unlocking these benefits for the state of North Carolina (See **Figures 5 and 6**).

Figure 5. Light-Duty Vehicle Cost-Benefit Analysis

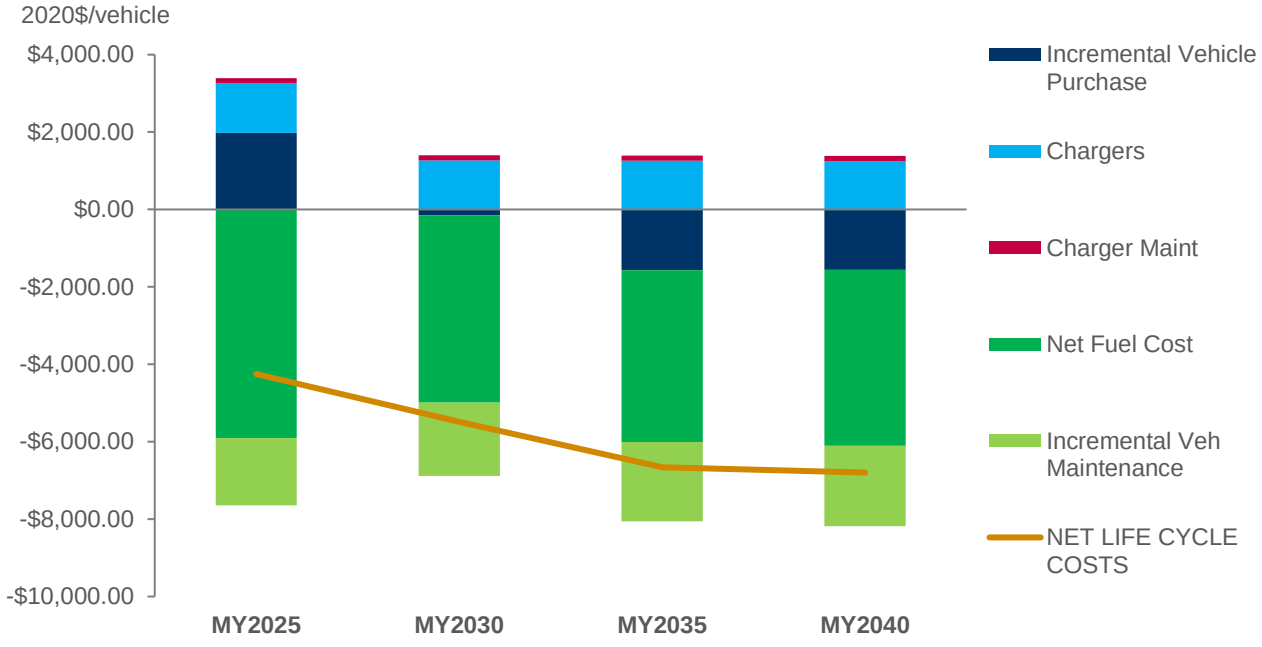
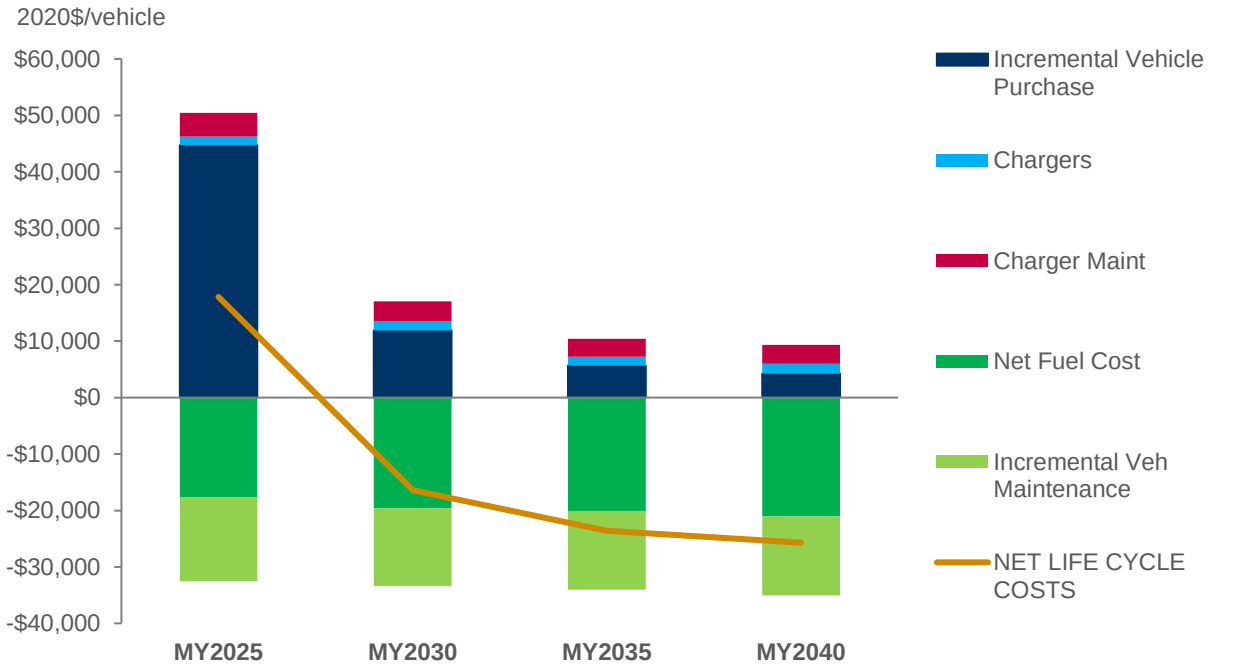


Figure 6. Medium- and Heavy-Duty Vehicle Cost-Benefit Analysis



The following sections of this Roadmap identify existing barriers and opportunities to scaling the light-duty and medium-heavy duty electric vehicle market by identifying which policies and programs may have an outsized impact on the development of a robust electric vehicle market within the State.

3. MARKET BARRIERS & EXISTING GAPS TO TRANSPORTATION ELECTRIFICATION

The electric vehicle market in North Carolina faces numerous barriers. Without strategic policy intervention, these barriers could hinder the State's ability to achieve the full benefits of the policies outlined above. Barriers include: 1) accessibility, not only to electrified vehicles but also access to charging networks; 2) affordability; and 3) electric vehicle awareness. Each of these is described in more detail below.

Communities and customer segments across the State each experience many of the barriers described below but will not necessarily respond to the same set of policy interventions. While many of the policy approaches described throughout this report impact a number of these segments, some market segments — because of differences in socio-economic characteristics, vehicle usage patterns, turnover rates, and vehicle availability — may require unique strategies.

- **Accessibility:** The opportunity to enjoy the benefits of clean, electrified mobility must be shared widely across the State. Ridesharing and ride hailing services (Transportation Networked Companies [TNCs]), as well as taxis, will also be part of the solution, as can innovations in the expansion of the used car market to boost access to electric vehicles for customers who cannot afford the purchase price of a new car.

  Additionally, there must be an accessible, customer-friendly vehicle purchasing and charging experience. The current vehicle marketplace is still nascent and must grow and develop to achieve State vehicle electrification targets. This type of development will require effective marketing, increased education on both lifestyle changes (e.g., charging), and available incentives for customers.[l] Accessibility also includes easy access to public chargers. Public charging infrastructure needs to be located in places where people typically go – schools, recreation centers, hospitals, libraries, parking garages, shopping centers, transit centers, and existing gasoline and convenience stations – as well as within state and municipally owned properties and public areas across the State.

- **Affordability:** The up-front costs are still high for most models of electric cars and light-duty trucks. Some studies have predicted the purchase price of EVs will match ICE vehicles within years, and certainly within the decade. As battery prices fall, the price of a battery electric vehicle (BEV) is expected to fall below that of a gasoline vehicle. The modeling done for this report (see **Appendix A**, Economic Impacts section for additional detail) incorporates an assumption that LDVs with a range of 200 miles becoming cheaper than ICE vehicles in 2026 while BEVs with a 300-mile range become cheaper than ICE vehicles in 2028. For MHDV and PHEVs total lifetime ownership costs will be net negative and will start providing savings for the vehicle owner around model year (MY) 2030, through fuel and maintenance savings from EVs.

  While total cost of ownership is lower than gasoline vehicles, many fleets and individuals look at upfront costs when making their budgetary and purchasing decisions, rather than savings that would accrue over the lifetime of a vehicle. Additional savings that should be considered and make EVs attractive even before the purchase price of EVs become comparable to ICE vehicles include vehicle maintenance savings and fuel savings. There should be additional education on these other EV benefits to make them more attractive to perspective buyers. However, these higher upfront costs particularly affect low-to-moderate income families, who face barriers to achieving benefits of transportation electrification. While state, federal, and manufacturer rebates and tax credits can help lower the cost, awareness of those opportunities needs to be more widespread, and efforts must be taken to help spur adoption in communities where a high up-front cost is a key limiting factor, including for charging infrastructure. Utilities can help alleviate upfront costs to EV ownership by providing customers with time-of-use (TOU) rates, net metering, or rebates.

- **Awareness:** Individuals and fleet owners alike must become increasingly aware of the basics of electric vehicle ownership including information about the benefits and advantages of EVs, the high quality of vehicle performance, vehicle ranges, the availability of models, and the ease and options for vehicle charging.

Table 4. Primary Implementation Barriers by Market Segment

This table briefly highlights the primary barriers to implementation by market segment. Each of these barriers are discussed in more detailed in the following sections.

Market Players and Impacted Entity		Primary Barriers
Light-duty Market Segments	**General Public**	• Lack of EV awareness and understanding of existing offerings • High upfront costs and lack of available models • Perceived performance concerns • Infrastructure and installation concerns
	Ridesharing/TNC	• High upfront costs • Concerns surrounding charging availability and easy access to charging locations • Lack of used EVs • Lack of EV awareness and understanding of existing offerings • Infrastructure and installation concerns
	Private Fleets	• Existing vehicle procurement cycles limiting uptake of EVs • Lack of available models, esp. of certain vehicle types (e.g., SUVs and Trucks) • Lack of EV awareness and understanding of existing offerings • Infrastructure and installation concerns
	State and Municipal Fleets	• Existing vehicle procurement cycles limit uptake of EVs • Lack of available models, especially of certain vehicle types (e.g., SUVs and Trucks) and in the near term • Performance concerns for public fleet purposes (e.g., emergency vehicles) • Infrastructure and installation concerns
	Low- to Moderate-income and Disadvantaged Communities	• Lower household incomes and homeownership • Lack of charging or parking availability, esp. in multi-family housing • Less vehicle ownership, esp. new vehicle ownership • Lack of investment interest in charging infrastructure • Lack of available used models
Customer Segments and Communities	**Rural Communities**	• Lower household incomes • Lack of available models, esp. of certain vehicle types (e.g., SUVs and Trucks) in the near term • Lack of investment interest in charging infrastructure

		• Less new vehicle ownership • Longer daily vehicle trips • Older populations (potential lack of desire to implement newer technology)
	Urban and Suburban Communities	• Curbside charging, siting, and installation concerns • Increased multi-family housing • Lack of available models, esp. of certain vehicle types (e.g., SUVs and Trucks) • More public transportation but considerable first/last mile considerations
	Electric Vehicle Supply Chain	• Lack of dealership offerings and educational resources • Lack of consistent and equitably distributed charging infrastructure • Lack of electric vehicle workforce training and retraining for repair and automotive supply industry • Lithium- ion battery end of life concerns and vehicle manufacturing supply chain concerns • Lack of available models esp. of certain vehicle types (e.g., SUVs and Trucks)
Vehicle Supply Chain	**Oil and Gas supply chain**	• Lack of workforce retraining programs across entire supply chain (gasoline suppliers to convenience store operators)
	Electric Utilities	• Lack of clear fleet planning projections • Lack of flexibility in utility planning processes • Concerns surrounding future load characteristics and buildout of grid infrastructure to meet new load • Lack of rate designs and other incentives to alleviate new grid load

4. COMPLEMENTARY POLICY ROADMAP

The core policies described above (i.e., policies that set standards for light-, medium-, and heavy-duty vehicle electrification like the ACCII or NOx Omnibus rules) are achievable in North Carolina and aligned with the State's ambitious electric vehicle goals. However, as described in detail above, the State, like many across the country, faces many barriers to the rapid electrification envisioned by these policies. Some of these barriers can be lowered with complementary policies that streamline process, increase awareness, and otherwise encourage greater vehicle adoptions. The Roadmap below highlights five categories of policies that will be critical to meeting the State's goals strategically, cost effectively, and equitably.

4.1 Infrastructure Development

As North Carolina vehicle market segments begin to electrify, developing both adequate residential, commercial, and fast charging networks that span the entire State, are reliable, and service multiple electric vehicle types will be important. This analysis projects the state will need 9 million charging ports to support the deployment of the ACT and ACC II within the state. The timely development of this level of charging infrastructure will require robust coordination and planning amongst key stakeholders. State leadership can play a key role in developing a space where stakeholders such as utilities, municipalities, fleet operators, and electric vehicle supply equipment (EVSE) providers can work together to identify what infrastructure will be required for different market segments and locations to electrify. While there are commonalities across states and regions, when actual infrastructure is beginning to be installed and as vehicle deployments scale, state leaders will need detailed and forward-looking electrification planning processes that consider the rollout of various vehicle types and where they are likely to charge or be refueled.

Without clear plans and policies from the State that address customer concerns (e.g., range anxiety, infrastructure expense, and awareness of charging costs and potential demand charges across service territories and regions), vehicle owners may find the proposition of procuring a zero emissions vehicle too risky. By supporting a long-term planning process that includes the thoughts and insights of original equipment manufacturers (OEMs) or vehicle manufacturers, fleet operators and TNC companies, utilities, private infrastructure providers, government agencies, and community advocates, State leadership can begin to develop an electrification pathway that includes the differing needs of multiple stakeholders. The State has already begun to kick off a Clean Transportation Planning through both its implementation of EO 80 and EO 246 but will need to further refine its planning processes.

4.1.1. Current Policy Development

As directed by EO 80, the North Carolina ZEV Plan highlights several actions that the State can take to increase the availability of a robust electric vehicle network and to alleviate range anxiety. The State has highlighted consistent wayfinding signage, facilitating fast charging collaborations, developing workplace charging programs, and increasing charging availability in rest areas as key priorities.[5]

The Motor Fleet ZEV Plan Update provides the State with next steps to increase the ZEV adoption within the State fleet, including several infrastructure next steps, outlined below.[6]

- **Location Sustainability:** Analyze new charging infrastructure locations that are the most effectively utilized for EV adoption. Explore contracting options to include infrastructure in new buildings, leasing, and purchasing.
- **Minimizing Infrastructure Costs:** Work to reduce new charging infrastructure installation costs identified in location sustainability analysis (above).

- **Identify Funding Opportunities:** Continue to pursue funding opportunities to increase infrastructure. Take full advantage of EV charging grants offered through VW Settlement Phase Two. Identify and pursue federal funding opportunities.
- **Charging Stations on New State Parking Construction:** Where feasible, ensure all new building construction that includes new parking lots has at least two EV chargers. State construction should include the costs of EV charging infrastructure when assessing overall costs.
- **Expanding Infrastructure:** Build on existing infrastructure by establishing collaboration and partnerships with departments, local municipalities, universities, agencies, and other partners to ensure that current and new charging infrastructure can support the expansion of ZEV usage.
- **Leased Space:** State property will explore incentive options for leased office space. Future request for proposals for leased office space will include a request for detailed charging infrastructure. DOA will collaborate with other cabinet agencies to promote EV charging at leased sites where feasible.

Since the release of the Motor Fleet ZEV Plan in 2021, many of these recommendations are still in the early stages of development.

Recommendations

In addition to the recommendations that the state is already considering, North Carolina should also ensure that the following infrastructure elements are included within any future infrastructure development process.

- **Tier residential charger rebates based on income eligibility:** Prioritizing charger and vehicle incentives to low-income communities helps community members in both rural and urban populations better access electric vehicles.[7]
- **State, regional, and local governments should collaborate to invest in developing regional charging networks to ensure that both rural and urban communities have access to the infrastructure needed to support electrification:** Developing transportation corridors that provide opportunities for transit, train, and low emitting vehicles is critical to creating a robust transportation system for rural communities. Ensuring that state and municipal planning documents evaluate and prepare for an electrified transportation future will also be important to ensuring that communities do not fall behind in a changing transportation sector. For example, the City of Sacramento has developed a planning process with key performance metrics that place a high priority on evaluating a wide range of zero emission mobility options including active transportation, public transit, share vehicles and single-occupant vehicles.[8] These plans are evaluated every two years to ensure that progress is being made and that the goals outlined within the plan are still the most pressing barriers to vehicle electrification.
- **State policy makers should focus on increasing awareness around the benefits of electric vehicle ownership:** Local governments can partner with utilities and dealerships to conduct marketing campaigns to increase uptake across communities. As described above, differing market segments have differing barriers when it comes to electrification. Understanding these differences and developing policies and programs that target those barriers could lead to increased vehicle adoption across the State. The California Energy Commission (CEC) and the California Air Resources Board for example have partnered with Veloz to deliver quarterly electric vehicle sales data that is then published both on the Veloz sale's dashboard as well as the CEC's website.[9] Both websites provide current and accurate data on EV sales in addition to the benefits of vehicle electrification which have increased consumer awareness.
- **Develop a plan for accessing Federal funding from the passage of the Infrastructure Investment and Jobs Act (IIJA):** In November 2021, Congress passed IIJA which authorized

$1.2 trillion in total federal spending that includes funding for a wide variety of projects and programs including $2.5 billion in grants to build out electric vehicle charging infrastructure. By planning ahead for infrastructure funding, the State can also make itself more competitive for the additional competitive grant opportunities that were included within IIJA (See **Federal Programs Supporting ZEV Deployment** Call-out Box)

- **Partner with utilities:** Local utilities can offer technical expertise on charging infrastructure upgrades, support charging stations, and can provide, pending regulatory approval, several different types of programs designed to incentivize the deployment of chargers within both public and private spaces. Utilities across the Country currently offer rebates for chargers and have developed rate designs and programs that encourage charging in a way that minimizes both customer costs and impact to the grid. Other utilities also support the development of either front-of- and/or behind-the-meter infrastructure up to the actual charger—commonly referred to as “make-ready” infrastructure—and, more recently, have started to offer transportation advisory services for commercial entities looking to install EVSE. Utilities have long standing relationships with community members and have the technical skills required to coordinate the type, location, and power requirements for EVSE deployment throughout their service territory making them a critical stakeholder to the development of charging infrastructure throughout all communities, including both urban and rural (see **Utility Role in Light-Duty Electrification call-out** box below).
- **Work with EVSE Providers to ensure reliable and consistent charging experience:** Not only do electric vehicle drivers need charging infrastructure to be installed, but they also need to be maintained to ensure consumer confidence and limit range anxiety. The State should consider developing requirements for charging incentive recipients to maintain the chargers for several years.
- **Establish long term infrastructure build-out plans:** Utilities can provide essential insight about grid expansion costs and time requirements in addition to experience in how to prepare for shifting electricity use cases. Future proofing is a strategy that allows utilities to build-out charging infrastructure upgrades during the initial construction period to streamline the integration of future technological advances. Utilities can build-out electric vehicle charging infrastructure in projects to accommodate the future need for EV specific resources. State entities should work with utilities, fleet operators, and OEMs to ensure coordinated infrastructure build-out for both light-duty and medium-heavy duty vehicles. Providing a space for utilities, fleet operators, state entities, and vehicle manufacturers to share their distinct and critical expertise will be essential to ensuring that infrastructure build-out plans are factoring in all critical information.

4.1.3 EVSE Installation Considerations

As discussed above, ensuring an adequate and equitable deployment of EVSE will be necessary to both support and drive further adoption of electric vehicles. While state policy to support financing and installing infrastructure is critical, so too are complementary policies and actions that ensure that the State creates an environment to maximize benefits of this infrastructure and deploy it efficiently and cost-effectively.

One way in which the State could improve its EVSE installation time would be to update and maintain its building codes. The *North Carolina Clean Energy Plan* recommends that the Building Code Council modernize the state’s building code to ensure that new buildings to have EV-Ready parking spaces by

incorporating EV infrastructure into building code requirements for new developments.* Building infrastructure at the onset of a project can bring down charger installation costs significantly compared to building retrofits.[10]

In addition to implementing new EV-Ready building codes, when developing electric vehicle supply and equipment policies, the State should:

- **Ensure sustained engagement of leaders in disproportionately impacted communities at every stage of the planning process:** This can help ensure that the process: 1) includes comprehensive, insightful documentation of existing conditions; 2) considers socio-economic and health conditions and develops strong partnerships between public health and planning; and, 3) measures projected health impacts of scenarios.[11]
- **Include effective curbside charging and parking strategies:** Enable a better use of the street and parking structures by creating fluid parking usage options for logistics firms, transit operators, TNC drivers, in addition to pedestrian and bicycle users, that fluctuate depending on the time of day and by electric application, including electric-preferred locations.†

4.1.4 Equity Considerations

Electric vehicle charging infrastructure planning and development must consider different types of community needs. Not all areas will benefit from the same amount or type of electric vehicle charging infrastructure. Ensuring that rural areas and renters, for example, have access to charging infrastructure will be integral to North Carolina's decarbonization strategy.

The regional and local transportation planning approaches outlined below place a priority on community engagement in addition to placing a priority on compact mixed-use developments that puts a priority on alternative modes of transportation.

- Carry-out authentic, sustained engagement of leaders in low-income communities of color at every stage.
- Build comprehensive research and data on both socio-economic status and health of communities that yields policy recommendations, which reflect the priorities and needs of low-income communities in the context of regional growth and change.
- Build strong partnerships between public health and city planning bodies.
- Increase vocational training for electric vehicle technicians and electrical workers to ensure electric vehicle and charger maintenance skills are available in urban and rural communities. Increasing workforce and vocational training will allow North Carolinians across the state to have access to high paying clean energy jobs.
- Ensure that an equity component is built into all long-term planning documents to ensure that plan implementation addresses the needs of all communities. This means ensuring relevant data and stakeholder engagement has informed any policy or plan, considering all potential impacts on all communities within the region.

* EV-Ready infrastructure ensures that new developments are capable of supporting electric vehicle charging and have the necessary components pre-wired in anticipation of the installation of charging infrastructure for the future.

† Electric preferred locations refer to parking or loading zone locations that prioritize or restrict access to electric vehicles as an added incentive to drive an electric vehicle.

Federal Programs Supporting ZEV Deployment

The Infrastructure Investment and Jobs Act (IIJA) was signed in November 2021 and provides unprecedented funding levels for electric vehicle charging infrastructure. While much of the funding is targeted towards LDV electrification there are several initiatives that also support M/HDV electrification, especially buses.

IIJA sets the stage for significant investments nationwide and there will be many opportunities for North Carolinians to benefit. Most of the programs related to vehicle electrification are to be implemented between federal fiscal years 2022 and 2026.

In broad terms, IIJA establishes funding appropriations for new and existing federal programs for surface transportation, energy infrastructure, transit, ports and waterways, and airports, among others. In addition to increases to existing program budgets, several new programs will be created to deploy EV charging infrastructure as well as other pathways towards vehicle electrification.

The IIJA funding will be critical to reach increased EV penetration outlined in core policies that North Carolina could choose to adopt. Most recently in EO 246, North Carolina set the same EV goal as the Biden Administration's EV goal, which is to have 50 percent of new vehicles sales be zero emission for the LDV sector by 2030. North Carolina could also choose to adopt M/HDV adoption goals such as an aggressive ACT program, which would set the goal of reaching 100 percent M/HDV sales be ZEV after 2040. To reach these increased EV adoption goals, significant investments will be needed, especially for EV charging infrastructure, and IIJA funding is an opportunity for the state to offset some of these anticipated costs. The modeling of core policies found that the High and High (Clean Grid) Scenarios that includes the adoption of the ACCII, ACT, and the NOx Omnibus Rule will require 9 million charge ports and approximately $1.2 billion of investments per year (2020$) by 2050.

Several key programs are identified below.

Charging & Fueling Infrastructure Grants: Eligible recipients (states, metropolitan planning organizations, local governments) will compete for funding for projects that align with the program goals – to strategically deploy publicly accessible EV charging infrastructure and hydrogen, propane, and natural gas fueling infrastructure (eligible fueling infrastructure) along designated alternative fuel corridors or in certain other locations that are accessible to all drivers of such vehicles. There is up to $2.5 billion in funding available through two competitive grants, $1.25 billion is focused on community charging infrastructure and the remaining $1.25 billion is focused on corridor charging infrastructure. Grants of up to $15 million will be awarded. These grants can help support infrastructure needed to support a rapid expansion of light duty vehicles under ACC II.

National Electric Vehicle Formula Grants: States will receive funding via a formula grant calculation, to be used for: (a) the acquisition and installation of EV charging infrastructure to serve as a catalyst for the deployment of such infrastructure and to connect it to a network to facilitate data collection, access, and reliability; (b) proper operation and maintenance of EV charging infrastructure; and (c) data sharing about EV charging infrastructure to ensure the long-term success of investments made under the program. These funds can be used to support, maintain, and integrate infrastructure needed to meet charging demand that would arise from ACCII. Under the National Electric Vehicle Formula Grant, North Carolina can access up to $109 million in funding.

Carbon Reduction Program (Climate): This is a new program that requires states to establish carbon reduction programs to reduce transportation emissions. North Carolina could build a transportation sector plan that is based on the core policies outlined above. Funding can be used for publicly accessible EV charging infrastructure or hydrogen, natural gas, or propane vehicle fueling infrastructure and the advancement of port electrification. This is a formula grant program with approximately $6.4 billion in funding that will be allocated to states. For FY 2022, North Carolina will receive $32.8 million, with additional funding to be released through FY 2026.

Surface Transportation Block Grants: This is an existing flexible funding mechanism that allows states and localities to address transportation needs and includes new eligibility for EV charging infrastructure. This formula grant program provided approximately $370 million to North Carolina in FY 2022, with additional funding to be released through FY 2026.

4.2 Vehicle Financing

Financing transportation electrification will require the collective resources of federal, state, and local entities in addition to private sector funding. While each of these funding streams will be important to the development of many of the policies and programs described within this roadmap, it is important that North Carolina think critically about how and where these investments should be deployed to achieve the greatest impact. This will mean not only stacking policies and programs in a manner that will create a sustainable market for electric vehicles but, also developing policies that address specific market barriers that vary based upon differing customer segments and communities across the State.

4.2.1 Current Policy Development

The State has already implemented several policies that can help lower the overall costs of owning and operating electric vehicles, though these fall short of direct incentives or financing opportunities for most vehicle types. These include:

- High occupancy vehicle (HOV) lane exemption for qualified plug-in electric (PEV) and fuel cell electric (FCEV) vehicles;
- Emissions inspection exemption for qualified PEVs and FCEVs; and a
- Limited grant program for alternative fuel vehicle (AFV) idle reduction technologies and diesel retrofits funding provided through the Clean Fuel Advanced Technology project.

Recommendations

A few additional considerations are highlighted below:

- **Develop policy objectives to help better align grant programs with zero emission transition needs:** Shape programs to focus less on a one for one replacement with diesel vehicles and more on easing ZEV adoption barriers. For example, the State could work with key stakeholders to develop grant programming that supports corridor infrastructure development or that provides funding for fleet advisory services.
- **Allocate funding across the M/HDV sector to address unique needs:** Based on current model availability, transit and school buses have the most mature pool of M/HD ZEVs. For other market segments, current commercial ZEV models are more limited and generally produced by small start-up manufacturers. Policies to help EV adoption in the M/HDV sector and to supplement the build out of charging infrastructure should be considered due to the high vehicle purchase costs and charging infrastructure costs specific to M/HDVs. Electric M/HDV purchase costs can, in some cases, double the purchase cost of a traditional ICE vehicle. In earlier years, like 2020, the difference in purchase cost of an average electric bus versus an average ICE bus could be as high as $125 thousand. While costs decrease overtime as technologies mature, for certain M/HDV classes, cost parity with ICE vehicles will not be achieved by 2050. For example, an average bus could continue to be approximately $77 thousand more than a traditional ICE bus by 2050. To meet increased EV penetration scenarios under the High and High (Clean Grid) Scenarios, over 650,000 depot charging ports must be built by 2050 for the M/HDV sector and an investment of approximately $135 million per year by 2050 will be required to meet those infrastructure needs. Though major delivery companies like Amazon and FedEx are making significant strides in procuring electric delivery trucks, smaller fleet operators who currently buy used vehicles find that new electric M/HDV are often cost prohibitive. While continuing to fund more mature markets, the State should consider targeting public funds—especially grant and incentive programs—towards sectors, populations, and locations that are not likely to be served

by the private sector in the near term. For example, a portion of limited public grant funding should be leveraged to support communities that are historically overburdened by pollution and implement rules like the Advanced Clean Fleets to ensure that medium- and heavy-duty vehicle fleets that serve and traverse these communities are electrified.

- **Introduce flexibility to finance vehicles and infrastructure:** Where the private sector is unwilling or unable to invest, State entities should take action by utilizing existing innovative financing mechanisms like the North Carolina Clean Energy Fund, the State's green bank, to help fund projects that cannot procure other traditional forms of funding. By working with State regulators to evaluate the role utilities have in supporting customer ZEV adoption, programs like on-bill financing and vehicle-to-grid models, in addition to soft cost initiatives (e.g., fleet advisory services), funding can be extended to a wider pool of applicants.
- **Consider targeting public funds:** Grant and incentive programs should be targeted towards sectors, populations, and locations that are not likely to be served by the private sector in the near-term. Particular focus should be given to supporting smaller fleet operators where high upfront costs may be more prohibitive or fleets operating within low-income and disadvantaged communities that experience disproportionate impacts of vehicle-related emissions. For example, the City of Charlotte has applied for a U.S. Department of Energy grant that would provide funding for a nationwide project to install a low-cost car-sharing EV program in low- and moderate-income communities with dedicated charging infrastructure in housing parking areas. Through federal, state, and local funding, Charlotte will invest $22.8 million into a contract with eTransEnergy to launch an electric bus pilot program that will test 18 battery electric buses. eTransEnergy will install and maintain the charging infrastructure and Charlotte Area Transit System (CATS) will own and operate all buses and related infrastructure. Lastly, the City has allocated funding for fiscal year 2022 with roughly $1 million to purchase 22 EVs for the City's fleet and $4.2 million to purchase electric buses and supporting infrastructure for airport services.

4.2.2 Incentives

The following section provides more detailed examples of incentives that the state should consider, including tax credits and fees, rebates, and voucher incentive programs.

4.2.2.1 Tax Credits and Fees

Tax credits are another mechanism to alleviate the high cost of ZEVs. Tax credits are designed to encourage adoption of a nascent technology and spur innovation. They are often developed with a declining incentive structure to lower the incentive as adoption rates grow and as the market becomes self-sustaining. Alternative models at the federal or state level could include creating an Investment Tax Credit or other type of credit for M/HD alternative fueled vehicles specifying a certain weight threshold.[12]

In the long-term, other mechanisms will need to continue to support an ever-growing system. As more consumers convert to ZEVs, states are grappling with how to make up for lost revenue from state gasoline taxes—which provide nearly 40 percent of transportation funds nationally.[13] Some states are implementing additional ZEV registration fees to fill this gap or utilize funds to build out ZEV infrastructure. While it is important that EV drivers "pay their fair share" for using the roads, it is vital that states do not develop policies or solutions that inequitably punish drivers for choosing cleaner or more efficient vehicles, while also not stymieing the growth of the EV market. In North Carolina, alternative fuel vehicles are exempt from the State's retail sales and use tax, under North Carolina General Statutes 105-164. [14]

Complementary or alternative revenue sources to an EV fee could include charges for road usage, applicable to all drivers who utilize North Carolina's infrastructure (i.e., a road usage fee)—not exclusive

to those who drive alternative fuel vehicles. Across the country, state and regional pilot programs are exploring fuel tax alternatives like vehicle miles traveled (VMT) or mileage-based user fees (MBUF) utilizing funding from the Federal Surface Transportation System Funding Alternatives (STSFA) grant program.[15] However, the Natural Resources Defense Council (NRDC) indicates that VMT fees neglect to acknowledge that heavier vehicles are not only responsible for emitting more pollution than lighter vehicles but also are responsible for the majority of damages found on roads. NRDC finds that replacing the federal gas tax with a VMT fee would result in 45 million more tons of greenhouse gas emissions annually since VMT fees do not discourage weight or encourage efficiency. Rather, EVs should be taxed as if they used gasoline, meaning they should be assessed with an annual fee based on miles-per-gallon-equivalent rating. Using this model in conjunction with indexing fuel taxes to inflation and total fuel consumption, will result in a higher adoption of electric vehicles thus overtime stabilizing states transportation funding.[16]

Recommendations

- **Consider alternative fee structures that can be applied across vehicle types:** Alternative structures should adequately account for all drivers' impact on the transportation system.

4.2.2.2 Rebates

Rebates also help bring down the price of new ZEVs and can be offered at or after the point of sale and have been successful in accelerating the EV market. Point-of-sale rebates reduce the purchase price of a vehicle at the point it is purchased as a "cash on the hood" deal. Point-of-sale rebates can have the benefit of improving accessibility of ZEVs to low-and-moderate income households by limiting the amount of funds that a consumer has to supply when purchasing a vehicle. New York offers a point-of-sale rebate of up $2,000 to residents that purchase or lease a new electric vehicle. Residents can choose from more than 60 pre-qualified electric models and rebate amounts are determined by the EPA all-electric range.[17] Through the state of Connecticut's multi-pronged CHEAPR program, residents have access to rebates of up to $9,500 for the purchase or lease of a new or used electric or hydrogen vehicle. The program is comprised of the CHEAPR Standard Rebate program offered to residents who purchase or lease a new eligible vehicle from a Connecticut franchised new automobile dealer or original equipment manufacturer; Rebate+ New program offered to residents who purchase or lease a new vehicle and participate in certain income qualified programs; and the Rebate+ Used program offered to residents who purchase or lease a used eligible vehicle and participate in certain income qualified programs.[18]

For other rebates, the benefit occurs as a return after the original upfront payment. Massachusetts offers residents with an after point-of-sale rebate of up to $2,500 for the purchase or lease of a new eligible vehicle. The MOR-EV program allows residents to purchase an eligible electric vehicle under $50,000 and qualify for an after-purchase rebate of $2,500 for new battery or fuel cell electric vehicles and $1,500 for new plug-in hybrid electric vehicles. Fleet owners may also apply for MOR-EV rebates for up to 10 vehicles per year and 20 vehicles over the program lifetime.

States across the country have also deployed M/HD incentive programs as well. For example, New York's Truck Voucher Incentive Program offers between $30,000 and $385,000 for fleets that purchase or lease BEV, Plug-in Hybrid-Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV), hybrid, Compressed Natural Gas (CNG), or propane Class 3-8 vehicles and scrap a similar older diesel vehicle that is part of their fleet. New Jersey's Zero Emissions Incentive Program (NJZIP), allocates $15 million to support businesses and institutions in purchasing new, medium-duty (Class 2b-6) ZEVs that will operate in the greater Newark and Camden areas. Small businesses receive a $2,000 bonus per vehicle scrapped and replaced with a NJ ZIP Voucher-Funded ZEV.

Recommendations

- North Carolina should adopt a rebate program that includes rebates that are offered at or after the point-of-sale to accommodate varying consumer needs across LD and M/HD vehicle sectors.

4.2.3 Additional Financing Solutions for ZEVs

While each of the above strategies can incentivize and support M/HD ZEV deployment, additional support will be needed to spur increased growth in the ZEV market. While public grant programs have and will continue to be important factors in lowering the upfront cost of M/HD ZEVs, public actors can provide additional support by using public funding to draw in private funding streams—making public dollars go further and enabling more consistent funding that is not tied to a singular source. Increased financing options coupled with additional non-financial support mechanisms discussed throughout this section can de-risk the transition to M/HD ZEVs, making it easier for fleet operators and other key stakeholders to begin to transition their fleets.

To support the ZEV market transition and to enable that the market reaches the scale needed, providers of public finance and fleets should draw widely from a variety of financing approaches, targeting solutions that meet specific vehicle sectors and use case requirements. The following approaches can be supported through both public and private entities and highlight several emerging approaches to financing the transition to ZEVs.

- **Leasing Models** have already been deployed, including vehicle leasing, battery leasing, and lease-to-own models. Leasing can lower the upfront cost of the vehicle and can make procuring vehicles less risky from an operation and maintenance viewpoint for fleet operators. While some fleet operators (e.g., trucking fleets) are used to leasing vehicles, leasing is not used as frequently with other M/HDV fleets (e.g., transit fleets). Some OEM manufacturers, like Proterra, have started to implement battery and vehicle leasing options for their bus fleet clients. In certain circumstances, existing grant programs may require vehicle ownership for participation. Increasing flexibility to enable lessee participation in grant programs may provide additional financing opportunities for fleet operators.
- **Green Banks** have been developed across the country to facilitate private investment in low carbon, climate-resilient infrastructure. The Connecticut Green Bank found that for every $1 of public funds committed by the Green Bank, an additional $6 in private investment resulted.[19] For many years, green banks have been used to primarily finance renewable energy deployment and energy efficiency upgrades. More recently, several have begun exploring financing models to support transitioning M/HD vehicles to ZEVs. Example programs include investing in EV production and/or charging infrastructure, financing EV fleet leasing or purchasing, or financing EV battery leasing. The North Carolina Clean Energy Fund is a non-profit financial institution that operates on a “Green Bank” model and is currently working to raise initial capital and operating funds.[20]
- **Vehicle to Grid (V2G)** projects offer the potential for an additional revenue stream for fleet operators by allowing either the fuel cell vehicle or the battery electric vehicle to communicate with the power grid to provide demand response services to the utility. School bus fleets have shown increasing feasibility for V2G projects due to their long idle periods during the middle of the day and, more importantly, their potential to serve almost exclusively as a battery during summer months when school is not in session. Several utilities across the country have deployed pilot programs with school bus fleet operators to evaluate the effectiveness of V2G programs (see *Utility Vehicle to Grid Projects* call out box).

- **Pay-As-You-Save (PAYS) Model** enables utilities to pay upfront capital costs and be reimbursed over time by the fleet operator through on-bill financing. M/HDV electrification has parallels to existing energy efficiency programs (e.g., rooftop solar) in terms of large up-front capital costs and long payoff periods. The PAYS model has proven effective for energy efficiency and can be deployed in a similar way within the transportation sector; it is now being actively explored in cities and states across the U.S., including Arizona and North Carolina. However, safeguards are necessary to ensure that low- and moderate-income customers are protected from potential predatory practices.
- **Transport Energy Service Company (T-ESCo) Models** split responsibility between the operator, procurement company, government, and infrastructure company. In this model the T-ESCo purchases the equipment or infrastructure for fueling the vehicle. This reduces the risk to the operator by lowering infrastructure costs and spreading those costs across multiple fleets. The operator pays the T-ESCo back over time with the operational savings they accrue. While this type of model has been deployed with compressed natural gas (CNG) transit buses it has not been used for M/HD ZEVs, though it is possible that a similar model could be deployed for FCEVs or EVs.

Recommendations

To ensure appropriate implementation of these programs, North Carolina officials should consider two overarching design considerations:

- **Support the development of pilot programming where appropriate:** Many of these policies would need to be tested and possibly subsidized using public funds. However, for those programs that have already been proven successful in similar situations in other jurisdictions, North Carolina should ensure that it moves directly to implementation to avoid unnecessary delays.
- **Encourage and implement public-private partnerships and collaborations:** State entities should work to increase engagement with the private sector on ways to increase funding opportunities to scale ZEV deployment. This could be through the deployment of many of the more innovative financing mechanisms described above utilizing either existing state funding (e.g., VW settlement funds) or anticipated IIJA funds.

4.2.4 Utility Program Design

Implementing effective rate design can enable fleet operators to cost effectively electrify and ensure that utilities will be able to efficiently manage new electric vehicle charging load in a way that does not negatively impact grid reliability. This analysis displays that customer savings could reach as high as $250 million by 2050, for the High (Clean Grid) modeled scenario when greater amounts of vehicles are charged on the grid and are likely to outweigh the costs of increased generation and transmission as well as the cost of additional electricity building additional capacity into the electric system (See **Appendix A**, Electric Utility Impacts for additional detail).

Investor-owned utilities (IOUs), cooperatives, and municipally owned utilities are all subject to different rules and regulations which may lead them to pursue one load management strategy over another. Utilities and state agencies should work together to evaluate which approach, or approaches, may work best within a given utility service territory, but can look to best practices from around the country.

The following approaches highlight a few ways in which utilities across the country are pursuing changes to their rates to promote managed charging.

- **Sector-specific rates:** Sector-specific rates can target offer specific tiered rate structure for different vehicle types. For example, a utility could provide a transit fleet rate that is designed to

match the duty cycle and usage pattern of the transit vehicle to encourage the fleet operator to develop a managed charging strategy. Sector specific rates can be very useful for M/HDV fleets that have very consistent load and usage patterns but need to be tiered effectively to accommodate the different types of vehicles that make up the M/HDV sector. It is also essential that these rates accommodate both the typical usage patterns of the vehicle and the needs of the grid to ensure that commercial and industrial customers are not overly burdened by costly demand charges but are effectively managing their load during peak periods. A number of utilities are currently considering this type of approach to rate design for EV charging. For example, San Diego Gas and Electric (SDG&E) has set a commercial EV rate that is tied to a monthly subscription fee. SDG&Es rate collects only marginal costs during the critical developing years of the market and gradually transitions to recovering embedded costs as the market matures, incentivizing the deployment of EVs within the commercial sector.

- **Tailoring rates to meet specific customer needs:** Tailored rates are not necessarily specific to electric vehicle use but target a certain behavioral shift from customers—either incentivizing or disincentivizing a behavior beyond what is typically included in a traditional rate. Some utilities offer time-of-use (TOU) rates, for example, that incentivize customers to reduce their consumption during peak usage hours. Others offer rates that incentivize service offerings that are beneficial for the community at large (e.g., by managing load to accommodate peak periods of use). For example, through its Business Incentive Rate, Con Edison also offers public DCFC stations, limited-term delivery rate reductions during the initial period of low station utilization. This program offers limited-term relief from operating costs while maintaining appropriate price signals that encourage demand management in EV charging. Tailored rates offer another way to modify rate structure to encourage managed charging without developing a rate that only targets one specific customer segment. Finally, certain programs give a utility the option to actively manage charging demand in exchange for a customer discount. The state is in the process of developing updated residential net metering policies that could provide a good incentive if applied to EV home charging.
- **Incentives placed on top of existing rates:** Some utilities have found that incentive programs can be a useful near-term option to encourage managed charging when compared to implementing specific or tailored rates. Since incentive programs are not tied to a ratemaking process, incentives can be modified more quickly and can be designed to be targeted towards customers with low, medium, and high usage rates. While these may be easier for utilities to implement and change, incentive programs may require additional communication and outreach to customers to ensure that eligible customers are aware of these program offerings. Con Edison's SmartCharge New York program, for example, uses a tracking system to reward EV drivers for off-peak charging.[19] Participants who charge in the Con Edison service territory receive $150 for installing and activating the monitoring device, $5/month for continuing to charge in the service territory and a bonus $20/month for avoiding summer-peak charging weekdays between the hours of 2 PM to 6 PM and $0.10/kWh for charging between midnight and 8 AM year-round. Additionally, participants can receive bonus payments for installing their device within one week, submitting feedback through annual surveys, and referring additional customers. Unlike Time of Use (TOU) rates, SmartCharge New York is an off-bill, nontariff program that monitors charging through a tracking system installed in the vehicle. Nonfleet participants receive their incentive on a monthly basis through PayPal and fleet participants receive rewards by check.

North Carolina Utility and Private Incentives

Cape Hatteras Electric Cooperative

- Electric Vehicle Supply Equipment (EVSE) Rebate: A $100 rebate to members who install a Level 2 (L2) ChargePoint home charger.

Duke Energy

- Park & Plug NC: Duke Energy will install, own, and operate up to 40 DCFC chargers, 160 L2 chargers in public locations and 80 L2 chargers at multi-unit dwellings.
- Duke Energy will offset the purchase of 15 electric school buses across the State to gather operational data and explore vehicle-to-grid technology.

Randolph Electric Membership Corporation

- EVSE Rebate Time-of-Use (TOU) Rate: A $500 rebate to members who install a L2 charger and participate in the REVUP program which encourages electricity use during off-peak times, part of the REVUP program.

Roanoke Electric Cooperative

- Time-of-Use (TOU) Rate: A monthly flat fee for up to an allotted kWh
- $50/month for up to 450kWh
- $39/month for up to 350kWh
- $31/month for up to 275kWh

Energy United

- Residential Plug-In Vehicles Charging Station Rebate: $500 to offset the initial cost of installing a charging station.

Surry-Yadkin Membership Corporation

- Time-of-Use Rate: A rate to encourage electricity use during off-peak hours.

4.3 Used Electric Vehicle Market

A consistent barrier to transportation electrification is the lack of used vehicles for purchase. The average light-duty vehicle in the United States today is 12 years old with many vehicles being sold and resold into secondary markets for another 10-20 years. This, combined with the reality that 70 percent of car sales in the United States are used cars, make developing this market essential for reaching mid-century transportation electrification targets.[10] The state of North Carolina will need to not only encourage the purchase of new electric vehicles but increase the turnover rate for both used ICE vehicles and new electric vehicles to reduce the amount of ICE vehicles on the road and increase the number of available used electric vehicle models.

Recommendations

Developing a used market for electric vehicles has the potential to dramatically reduce upfront cost thereby making electrification a more reasonable option for North Carolinians, including lower income residents who may otherwise be unable to afford the purchase price of a new vehicle. There are a variety of policies that could encourage the development of a used electric vehicle market:

- **Provide incentives for used electric vehicles:** Making them more cost competitive with used internal combustion engine vehicles.
- **Increase and incentivize public and private fleet turnover:** Increasing fleet turnover to electric vehicles in the near term will increase the number of vehicles within the secondary vehicle market.
- **Develop marketing and outreach plans:** Communicate and support used electric vehicle purchases.

Equity Considerations

Electric vehicle incentives and financing have historically benefited “early adopters” looking to purchase new vehicles by lowering the upfront costs. These incentives tend to overlook drivers who purchase vehicles in a secondary or tertiary market and some incentives, like tax credits, are not an effective incentive for many potential EV customers. To alleviate financial burdens, states, cities, and municipalities should reevaluate existing siting and zoning regulations that may have previously dissuaded owners from electrifying and provide curbside management incentives. Specifically, incentives should focus on serving low- to moderate-income drivers and residents in communities that are historically burdened by pollution to lower the upfront cost of an electric vehicle and include incentives for used EV purchases.

Traditional approaches to financing ZEVs have focused on bringing down the total cost of ownership to make ZEVs competitive with established ICE models, focusing mostly on capital and fuel costs. Federal, state, and local governments have implemented grant, incentive, rebate, and voucher programs to reduce the capital cost of the vehicle. For example, the state of Connecticut offers a rebate of up to $9,500 for residents who purchase or lease a new or used electric vehicle.[21] For M/HD vehicles, public funding to date has been largely deployed to implement scrap and replace programs, voucher incentive programs, and to reduce vehicle idling.

States considering implementing a scrappage program should ensure that rural communities are included, and that outreach is done to encourage program usage within rural communities. Scrappage programs, if effectively implemented, could be beneficial to rural communities which tend to have older, larger, and more inefficient vehicles. These programs could be more beneficial if they incentivized vehicle right-sizing by offering funds to trade-in larger vehicles for smaller, more efficient vehicles or for other mobility options. Studies have also shown that vehicle scrappage programs can also be very effective in high polluting urban areas where the air pollution is more significant.

The following key elements should be included to ensure an effective and equitable scrappage program is developed for the State.

- Replacement vehicles need to be ZEVs, replacing older vehicles with new ones that meet more stringent emission standards and have better fuel economy;
- Program implementation, management, and enforcement should ensure expected benefits are achieved by tailoring incentives to optimize both environmental benefits and cost-effectiveness;
- Offer different trade-in options for vehicle owners (e.g., vouchers for an e-bike or multi-year transit pass) in addition to offering vouchers for zero-emission vehicles; [22]
- Governments should consider implementing complementary fiscal policies with additional incentives directed at smaller fleets to ensure that vehicle replacement is feasible.

Additionally, the State can increase electrification opportunities for fleets that promote flexible work options, such as electric carpooling, vanpooling, and micro mobility to help increase low-carbon transportation options for those who choose not to, or are unable to, purchase electric vehicles.

4.4 Education and Outreach

Many communities across the country, especially low-income, underserved, and rural communities, are oftentimes less familiar with the potential benefits that transportation electrification could bring. In order to increase the deployment of electric vehicles, state and local governments will need to work with key stakeholders in communities to increase awareness around vehicle electrification. North Carolina has already begun to implement education and outreach programs across the state. Following the North Carolina ZEV Plan, the State has begun to coordinate Ride and Drive events to educate residents on topics such as EV pricing and affordability, vehicle range, and charging costs and options. In addition, the North Carolina Department of Transportation keeps track of the zero-emission vehicles registrations throughout the State to monitor EV transition.[23]

The City of Charlotte's Strategic Energy Action Plan address several education and outreach tasks. The City is working on rolling out an education program that will provide training on Eco-driving to all city staff. Charlotte will develop a promotion and awareness campaign around EV by creating a visible monthly event to educate the community around zero-carbon modes of transportation. To increase access to zero carbon mobility options, the City of Charlotte will actively work with CATS and other transportation stakeholders to develop a series of campaigns to overcome negative perceptions of public transportation and develop an app or similar platform that provides customers with a one-stop purchase of tickets for all modes of transit available in the City. North Carolina of Sustainable Energy Association (NCSEA), the North Carolina Justice Center, the Sierra Club, Sol Nation, and the Southern Alliance for Clean Energy (SACE), have joined together to participate in Forth's and the Greenlining Institute's TEEM group to help promote and deepen community engagement in the City of Charlotte around equitable mobility.

Other outreach initiative in the State includes the North Carolina Conservation Network (NCCN) and the North Carolina Department of Environmental Quality (DEQ) working together to facilitate equity-centered groups to support direct engagement with underserved communities; Duke Energy's Park and Plug initiative where Duke will install, own, and operate various EV charging infrastructure throughout the State; and the North Carolina Electric Membership Coalition is working with other electric cooperative throughout the State to deploy charging infrastructure and educate consumers on the potential financial and environmental savings on owning an electric vehicle.

While cities and private entities are providing education and outreach opportunities, it is imperative that the State is not only supporting these efforts but making them an essential part of the EV adoption process throughout the State.

Recommendations

As municipalities across the State begin to implement electric vehicle education and outreach programs, North Carolina should consider implementing the following policy approaches to increase awareness.

- **Develop statewide workforce ZEV training program:** North Carolina can work with public universities and community colleges to develop workforce training and career programs for new workers and support the existing workforce with on-the-job training.
- **Increase public awareness:** Designing and implementing a comprehensive and cohesive marketing program that can combat EV adoption barriers, such as range anxiety, by highlight the publicly accessible charging network around the State. North Carolina will need to implement a comprehensive digital promotion site for current and future EV users where information regarding the basics of an EV, procurement options, incentives and rebates, and the public charging network may be displayed.

- **Establish an EV infrastructure toolkit:** The State should provide local and regional governments with an infrastructure toolkit to 1) identify charger options, 2) provide utility contacts for the installation of supporting electrical equipment, 3) recommend qualified electricians, 4) identify rebates, and 5) detail local permitting requirements.

Equity Considerations

For many drivers, electric vehicles are still not well understood with many misconceptions about charging needs, reliability, and costs. Underserved and low-income communities are often even less familiar with EVs, including the potential benefits that vehicle electrification could bring. Crafting community specific campaigns, informed by careful stakeholder engagement, to address these outsized information gaps will foster better outcomes. Partnering with local organizations like EV Hybrid Noire and Plug-in NC, whom already have a robust network on the ground, to host educational programming (e.g., ride and drive events) will be integral to quickly and equitably educating a diverse set of stakeholders on the benefits of electrification, while also provide insight into the actual—and not perceived—needs of the community.[24,25] Other local organizations such as the North Carolina Justice Center helps provide insight on how to equitably distribute public investments and funds while fairly distributing tax responsibility throughout the State. Appalachian Voices is another organization that work for the equitable transition from fossil fuels to clean energy sources for rural communities throughout the State. The State should engage with these and other stakeholders throughout the state to increase understanding around the benefits of electrification to ensure that communities are not left behind and instead at the forefront of the transition to clean transportation.

4.5 State Leadership

State, county, and local governments should lead by example when deploying and promoting clean transportation systems both within their own fleets and throughout the community. Government driven initiatives not only increase electric vehicle awareness, but they also improve air quality and have the potential to create government fleet operation and maintenance savings. Within their own LDV fleets, government fleet operators can begin transitioning to electric vehicles by setting fleet electrification procurement targets. In the short term, when access to certain vehicle types is unavailable (e.g., light-duty trucks), it will be important for fleet operators to consider vehicle usage patterns to determine if certain vehicles that do not currently have an electric vehicle alternative could be replaced with other light-duty electric vehicles.

In addition, local governments should consider setting procurement targets for their transit fleets and public-school buses. Local governments have a unique opportunity to lead in the transition to electric vehicles and to do so in a way that creates increased mobility options for community members who may not have access to a personal vehicle. As is discussed below, as rural communities think about ways to decrease emissions from the transportation sector, increasing access to reliable public transit could be part of the solution. In some rural communities, this may mean creating a public transportation system where it may not have existed previously. This may enable rural communities to leap-frog traditional diesel transit vehicles and to deploy electric transit buses. Outside of their own fleet, local governments can encourage electric vehicle procurement by deploying vehicle charging infrastructure networks and by educating the public on the benefits of electric vehicles.

The State and a number of key municipalities across the State have begun to implement strategies to increase vehicle electrification both within their own fleets and also throughout the community, several stemming from Governor Roy's EO 80 and EO 246. A few notable examples are outlined below.

- **Clean Transportation Plan**: EO 246 directs the NC DOT, in partnership with DEQ, the North Carolina Department of Commerce, among others to develop a North Carolina Clean

Transportation Plan that recommends actionable near term strategies for decarbonizing the transportation system to the Climate Council by May 2023.

- **Transit Electrification:** In 2019, the City of Greensboro became the first transit agency in North Carolina to begin replacement of its diesel buses with battery electric buses. When the bus fleet completes its transition to electric drivetrains, it will be the second-largest fleet of electric buses on the east coast. Greensboro expects to save $350,000 over the lifetime of each bus in reduced operating and maintenance costs.[26]
- **Multi-state commitments:** On July 14, 2020, fifteen states, including North Carolina, and the District of Columbia signed the Multi-State Medium- and Heavy-Duty Zero emission Vehicle Memorandum of Understanding (MHD ZEV MOU). The signatories agree to ensure that 30 percent of all new medium- and heavy-duty vehicle sales are ZEV by 2030, and 100 percent by 2050. North Carolina is an active participant in the Southeast Regional Electric Vehicle Information Exchange Group. This group, comprised of 7 states, Puerto Rico, Duke University, and the National Association of State Energy Officials (NASEO), share information and best practices regarding EV infrastructure planning, education and outreach, policy development and implementation. These commitments will help develop standards and regulations, deploy infrastructure, and drive investment to advance EV adoption and reach State emission goals.
- **Utility Engagement:** Utility engagement is an imperative part in the electric vehicle adoption process as utilities can provide their customers with education and outreach programs, incentive and rebate programs, and time-of-use rates lowering the cost of ownership for EV owners. The State should leverage the opportunities utilities can provide to a large portion of the State's residents.
    - On October 13, 2021, Governor Cooper signed into law House Bill 951 which authorizes the utilities commission to undertake necessary actions to achieve a 70 percent reduction in carbon emissions from electric public utilities from 2005 levels by 2030 and reach carbon neutrality by 2050.[27]
    - The Electric Highway Coalition was founded by six major utility companies, American Electric Power, Dominion Energy, Duke Energy, Entergy Corporation, Southern Co., and the Tennessee Valley Authority. The Coalition announced in March 2021 to work collaboratively to bring a seamless network of electric vehicle chargers along major highway routes from West Texas up the East Coast and aims to install DC fast chargers that can charge in approximately 30 minutes. In July 2021, the coalition more than doubled, incorporating over ten new utilities.
    - On December 7, 2021, the Electric Highway Coalition merged with the Midwest Electric Vehicle Charging Infrastructure Collaboration to form the National Electric Highway Coalition. NEHC, consisting of over 50 investor-owned electric companies, one electric cooperative, and the Tennessee Valley Authority, is committed to providing public electric vehicle charging options along major U.S. highway corridors by 2023.
    - Duke Energy's Park and Plug program will install EV chargers throughout North Carolina to provide a foundational level of infrastructure to facilitate EV adoption and provide exposure to North Carolina residents. The utility will install, own, and operate up to 40 DCFC chargers at 20 different locations and 160 Level 2 chargers at various locations, and up to 80 Level 2 chargers at multi-unit dwellings. Simultaneously, Duke Energy will offset the purchase of 15 electric school busses by district to gather operational data and explore the impacts of vehicle-to-grid technology.[28]

- **Local Leadership:** Municipalities across the state have the opportunity to partner with and provide support for a wide variety of community outreach organizations to education local communities on the benefits of transportation electrification.
    - There are three Clean Cities Coalition designations in the state of North Carolina, Centralina Clean Fuels Coalition (2004), Land-of-Sky Clean Vehicle Coalition (Western North Carolina) (2012), and the Triangle Clean Cities Coalition (Raleigh, Durham, and Chapel Hill) (2001). All three coalitions collectively work together to reduce petroleum dependency in the transportation sector while developing an alternative fuel vehicle marketplace. Centralina Clean Fuels Coalition has an annual emission reduction of 18,000 tons of CO2e, Land of Sky Clean Vehicles Coalition and Triangle Cities Coalition have an annual emission reduction of 7,000 tons and 32,000 tons of CO2e, respectively.
    - Since 2011, Plug-In NC has been working with communities and organizations across the State to support electric vehicle adoption through education and outreach, consulting, and resource development collaboratively working with stakeholders to ensure seamless and equitable electric vehicle integration. The program will work with communities and organizations to identify the best course of actions when it's time to electrify.
    - Drivers of public policy such as the North Carolina of Sustainable Energy Association (NCSEA) work to enable clean energy jobs, economic opportunities, and affordable energy options throughout the State by keeping engagement and collaboration at their core focus. Working with the North Carolina Justice Center, the Sierra Club, Sol Nation, and the Southern Alliance for Clean Energy, NCSEA have joined together to participate in Forth's and the Greenlining Institute's TEEM Community of Practice initiative; equity, environmental justice and traditional environmental and clean energy organizations from Colorado, Illinois, and Virginia are also apart of TEEM. By building cross-state networks, the Towards Equitable Electric Mobility states will be better prepared to utilize future federal funding and resources more efficiently and equitably to advance electric vehicle adoption.[29]

4.5.1 Leading by Example

North Carolina can increase the number of zero-emission vehicles in the State by leading by example within its own vehicle fleet. Under the direction of *Executive Order 80*, the Department of Administration (DOA) published its initial *Motor Fleet ZEV Plan* in September 2019 which recommended that 572 of the State's fleet should be replaced with electric vehicles—resulting in $3.8 million in vehicle savings and a reduction in emissions by 22,000 metric tons over the lifetime of the vehicles.[30] Since 2016, the State's fleet has adopted 41 ZEVs. In October of 2021, the DOA published its *Motor Fleet ZEV Plan Update* which found 3,049 state vehicles are eligible to be replaced with zero-emission vehicles by the end of their lifetimes: potentially saving $14 million in total cost of ownership and reducing GHG emission by over 76,500 metric tons.[31] As was identified above, the State can take a meaningful step in electrifying all 143 vehicles it identified within its Motor Fleet Management Plan and should work to electrify all additional eligible vehicles in subsequent years.

To accelerate ZEV adoption in the State's fleet, the Division of Motor Fleet Management (MFM) worked with DOA Purchasing and Contracting to shift procurement from a "single winner-takes-all" contract to a "bid your portfolio" contract. This shift allowed for OEMs like General Motors and Ford and new dealers like Toyota, Hyundai, and Nissan to bid individual vehicle models in their portfolio, allowing North Carolina to purchase vehicles from a wide variety of manufactures based on specific vehicle needs. Using this new procurement contract, MFM was able to add several ZEVs to the fleet.[32]

Recommendations

State and local government should consider implementing the following policy approaches.

- **Encouraging low-emission travel:** North Carolina can encourage state employees to support local transit systems by providing free or reduced costs passes. GoTriangle, the regional transit system for Wake, Durham, and Orange counties, works with 50 employers to provide employees with the GoPass for free or at a low cost to encourage ridership.[33] As well, the State and its local governments should improve awareness of electric vehicle ownership by partnering with utilities and dealerships to deploy marketing campaigns and ride and drive events. The State could also consider incentives or education policies around the potential benefits of flexible work arrangements, drawing on the experience of many organizations operating through the pandemic.
- **Electrify Transit and Public Service Fleets:** Within their own fleet, local and state governments can set procurement targets to ensure that their fleet will be lower emitting as the fleet turns over. Within the LDV space, local governments should consider both increasing procurement targets and evaluating their current fleet to determine if the fleet could be reduced or if vehicle types could be changed (e.g., procuring an electric sedan in place of a pick-up truck) to enable a faster fleet electrification. Within transit and school bus fleets, regional and local agencies should develop electric vehicle procurement goals and should consider bus size when making procurement decisions. Rural communities may not require the same number of seats per bus as an urban community enabling rural transit operators to procure smaller buses which may help reduce the upfront cost of buses in addition to lowering charging needs. As a starting point, the State should electrify all 143 vehicles it identified within its Motor Fleet Management Plan and should work to electrify all additional eligible vehicles in subsequent years.
- **Develop Local and Regional Charging Networks:** State, regional, and local governments should collaborate to invest in detailed plans to develop regional charging networks.
- **Create job opportunities by incentivizing electric vehicle manufacturing in communities:** State and local leaders should consider providing incentives to vehicle manufactures that are looking to build electric vehicles within communities.

Equity Considerations

There are a variety of equity components to consider when addressing different electric vehicle market segments and many stem from demographic and socio-economic differences. For example, rural communities often lack adequate access to transportation alternatives and rely heavily on personal vehicles that are generally older, inefficient, and expensive to maintain and refuel. Compared to suburban and urban residents, rural residents tend to travel farther to work, to run errands, and to seek basic services such as healthcare and education, thus creating a long-term dependency on personal vehicles. Alternatively, low-income or underserved communities in urban regions tend to rely heavily on public transit and benefit less from state programs that target "early adopters" who purchase new vehicles. Low-income, underserved, and rural communities are oftentimes less familiar with the potential benefits that transportation electrification could bring. Ensuring that any implemented programs address the unique needs of each of these areas will be key to meeting statewide transportation decarbonization goals.

As North Carolina officials work to equitably decarbonize the State's transportation sector they should

- Commit to working directly with communities to understand their transportation needs.
- Ensure that rural households and multi-unit dwellings are included in federal and state electric vehicle incentive programs,

- Increase communication and education campaigns around the benefits of electric vehicles within communities,
- Offer additional financing options for low- to moderate-income residents and small businesses, and
- Provide tiered rebates based on income eligibility, as well as rebates for used vehicles.

The State can demonstrate leadership in fostering a Just Transition by ensuring that there is an equity component in all state level policy, plans, and roadmaps, and that programs are developed that directly target emissions reductions in overburdened communities. This means prioritizing authentic and sustained engagement with relevant stakeholders and local leaders to inform strategies targeted towards underserved and other minority communities.

5. CONCLUSION

The state of North Carolina has a tremendous opportunity to develop a comprehensive transportation electrification Roadmap that targets LD and M/HD vehicles and that supports the equitable growth of clean and reliable transportation for all North Carolinians. This Report highlights several high impact policies to drive electric vehicle adoption across the State by adopting both a collection of “core policies” that set standards for light-, medium-, and heavy-duty vehicle electrification and by highlighting a set of additional complementary policies that will ensure that the State’s transportation electrification goals are met strategically, cost effectively, and equitably.

These complementary policies, when combined with the modeled core policies, set the State on a pathway to ensure vehicle electrification is not only supported and North Carolina’s ambitious targets can be met but, the societal benefits of vehicle electrification can be maximized and distributed to communities across the State, particularly to those that are disproportionately burdened by climate change and transportation pollutants. These benefits—including improved air quality, reductions in climate warming GHG emissions, utility customer savings, and vehicle owner savings—will put the State on a pathway that centers climate action around environmental justice, equity, and affordability for all North Carolinians. Taken together, the actions outlined within this Roadmap will help the State meet its ambitious targets and secure significant benefits.

6. APPENDIX A: DETAILED MODELING TECHNICAL ANALYSIS

6.1 Introduction

ERM was retained to model three scenarios, identified by NRDC, reflecting differing levels of electric vehicle (EV) saturation under different policy actions.[*] This modeling can help to evaluate the costs and benefits of increased adoption of electric light-duty vehicles (LDVs) and electric medium-and heavy-duty vehicles (M/HDVs) across the State.

ERM has more than two decades of experience in the transportation sector. The modeling framework utilized in this analysis has been developed and refined over the past five plus years. ERM has conducted studies on the impacts of EV saturation in more than 20 states for a range of clients including non-profits, utilities, and state governments.

The modeling framework incorporates a range of inputs including emission factors, vehicle and maintenance costs, projected electricity prices, current state vehicle population, state electricity generation mix, and EV charging cost and use data. The framework estimates the impacts of EVs on fuel use and emissions, air quality and health, utilities, and EV owners as well as conducting an economic analysis and a gap analysis on needed EV charging infrastructure. All these components are monetized to understand the net societal benefits of EV adoption in North Carolina.

6.2 Inputs and Assumptions

6.2.1 Modeling Scenarios

The basis for the modeling scenarios were identified by NRDC. The LDV Scenarios include:

- A “Medium Scenario” for LDVs adopted the Biden Administration’s EV goal of achieving 50 percent of new passenger vehicles and light trucks sold in 2030 be zero emission vehicles.[†]
- A “High Scenario” for LDVs adopted California’s proposed *Advanced Clean Cars II* regulation, which requires vehicle manufacturers to sell increased levels of EVs starting in 2025 and reaching 100 percent sales by 2035.[‡]
- A “High (Clean Grid) Scenario” used the same vehicle adoption trajectories as the High Scenario, but also included a clean electric grid mix based on North Carolina’s HB951 Legislation.[§]

These three scenarios were compared to a Baseline Scenario that continue to meet EPA emission standards and EV sales that increase very slightly, reaching approximately 21 percent of passenger car sales and 12 percent of light truck sales by 2050.[**]

[*] An Electric Vehicle has a battery rather than a gasoline tanks as well as an electric motor instead of an internal combustion engine. Plug-in hybrid electric vehicles (PHEVs), which is included in this analysis as an EV, is a combination of gasoline and EVs, therefore they have a battery, an electric motor, a gasoline tank, and an internal combustion engine.

[†] Executive Order 14037, “Strengthening American Leadership in Clean Cars and Trucks,” https://www.federalregister.gov/documents/2021/08/10/2021-17121/strengthening-american-leadership-in-clean-cars-and-trucks

[‡] Advanced Clean Cars II Regulation is based off of CARB’s December 2021 “Draft Zero Emission Vehicle Regulation 1962.4,” https://ww2.arb.ca.gov/sites/default/files/2021-12/draft%20zero%20emission%20vehicle%20regulation%201962.4%20posted.pdf

[§] North Carolina’s HB951 Legislation requires a 70 percent reduction in emissions from the electric grid from 2005 levels by 2030

[**] The baseline EV sales assumptions are consistent with projection in the Energy I.

For M/HDVs, the scenarios considered the adoption of EVs, as well as increasing nitrogen oxides (NOx) tailpipe emission stringency for internal combustion engine (ICE) vehicles. These scenarios each increase in ambition, with the High (Clean Grid) scenario providing the greatest benefits to the State:

- The "Medium Scenario" included North Carolina fully adopting California's *Advanced Clean Truck* (ACT) Rule, plus their NOx Omnibus regulation. The ACT Rule requires an increasing percentage of new trucks sold in the State to be EVs beginning in the 2025 model year, and increases in stringency each model year between 2025 and 2035.[*] The NOx Omnibus regulation requires an additional 75 percent reduction in NOx emissions from engines in new gasoline and diesel trucks sold between model year 2025 and 2026, and a 90 percent reduction for trucks being sold beginning in the 2027 model year and beyond.[†] These low NOx vehicles makeup the remainder of vehicles sold that are not EV starting in 2025.
- The "High Scenario" included full adoption of both ACT and Omnibus plus increases in program ambition resulting in 100 percent of all M/HDV sales being EV after 2040.
- The "High (Clean Grid) Scenario" assumes the same vehicle adoption as the High Scenario but incorporates a clean grid mix akin to North Carolina's HB951 Legislation.

These three scenarios were compared to a Baseline Scenario in which all new trucks sold in the State continue to meet existing EPA NOx emission standards and EV sales that increase only marginally, never reaching more than 1 percent of new vehicles sales each year.[‡]

6.2.2 Generation Mix

In the modeling framework, the electricity generation mix and its evolution between 2021 and 2050 contribute to the reduction in emissions associated with EV adoption. If a generation portfolio is assumed to be a large emitter of greenhouse gases (GHGs), NOx, and particulate matter ($PM_{2.5}$, identified as PM going forward), the replacement of an ICE vehicle with an EV would have a limited impact on the overall state emissions. If generation is predominantly from zero-carbon sources, the impact of each EV will be significant.

Figure 1A shows a "business as usual" (BAU) generation mix based on NRDC's IPM Grid modeling (BAU Mix). By 2050 the grid mix reaches 3 percent coal, 28 percent natural gas, and 68 percent zero-emitting. This grid mix is used for the Baseline, Medium and High Scenarios for both the LDV and M/HDV classes.

[*] By 2035, zero emission truck sales need to be 55 percent of Class 2b to 3 truck sales, 75 percent of Class 4 to 8 straight truck sales, and 40 percent of combination trucks.

[†] Reductions are relative to current federal EPA new engine emission standards. This rule does not require additional PM reductions but includes anti-backsliding provisions to ensure that PM emissions do not increase compared with engines designed to meet current federal standards.

[‡] The baseline EV sales assumptions are consistent with projection in the Energy Information Administration's Annual Energy Outlook 2021.

Figure 1A. North Carolina Generation Mix (Business as Usual Scenario)

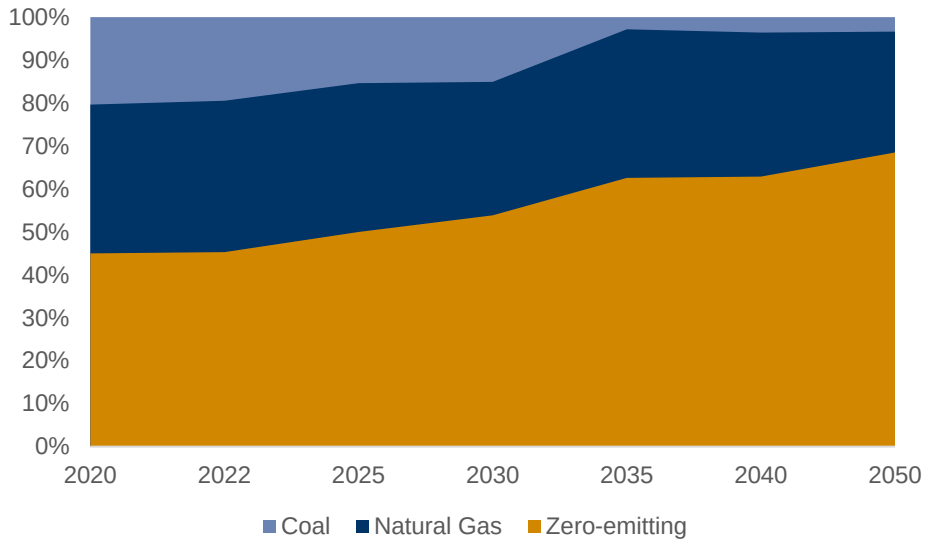
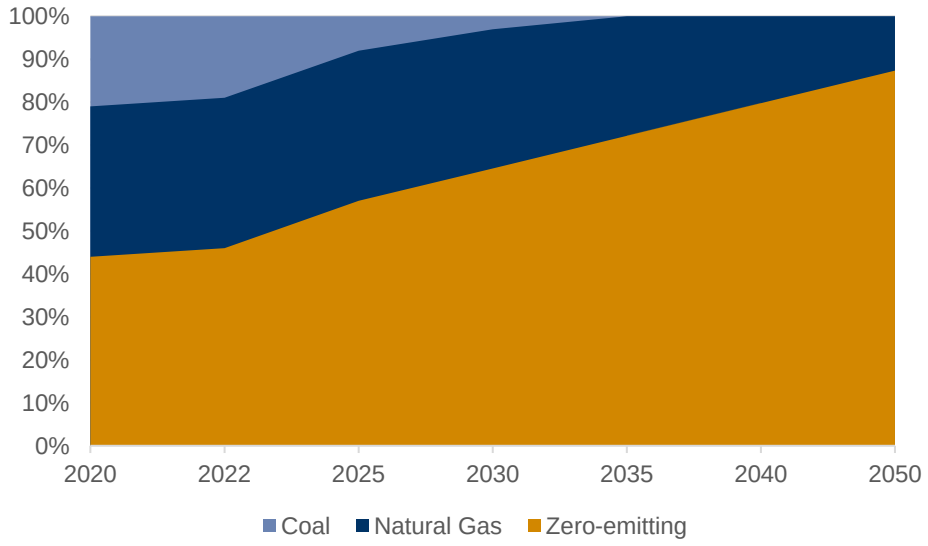


Figure 2A shows the electricity generation mix based on North Carolina's HB951 Legislation which reaches a 70 percent reduction in emissions compared to 2005 levels by 2030. In 2050, the grid mix includes 13 percent natural gas, and 87 percent zero-emitting. All coal generation is assumed to retire in 2035 under this grid mix. This clean grid is used for the High (Clean Grid) Scenarios for LDVs and M/HDVs.

Figure 2A. North Carolina Generation Mix (Clean Grid Scenario)



6.3 North Carolina Results

North Carolina's on-road fleet comprises of 10.3 million vehicles at the beginning of the modeling period in 2020 and 12.8 million vehicles by 2050, a 25 percent increase. The vast majority of those vehicles, approximately 92 percent, are LDVs and the remaining 8 percent are M/HDVs. Under the Baseline Scenario, by 2050 in-use light duty EVs reach 13.6 percent of total LDVs. For M/HDVs, in-use EVs

reach 0.9 percent by 2050. See **Figure 3A** for the percentage of new EV sales under the Baseline Scenario and **Figure 4A** for the percentage of in-use EVs for both LDVs and M/HDVs.

Figure 3A. Percentage of New EV Sales (Baseline Scenario)

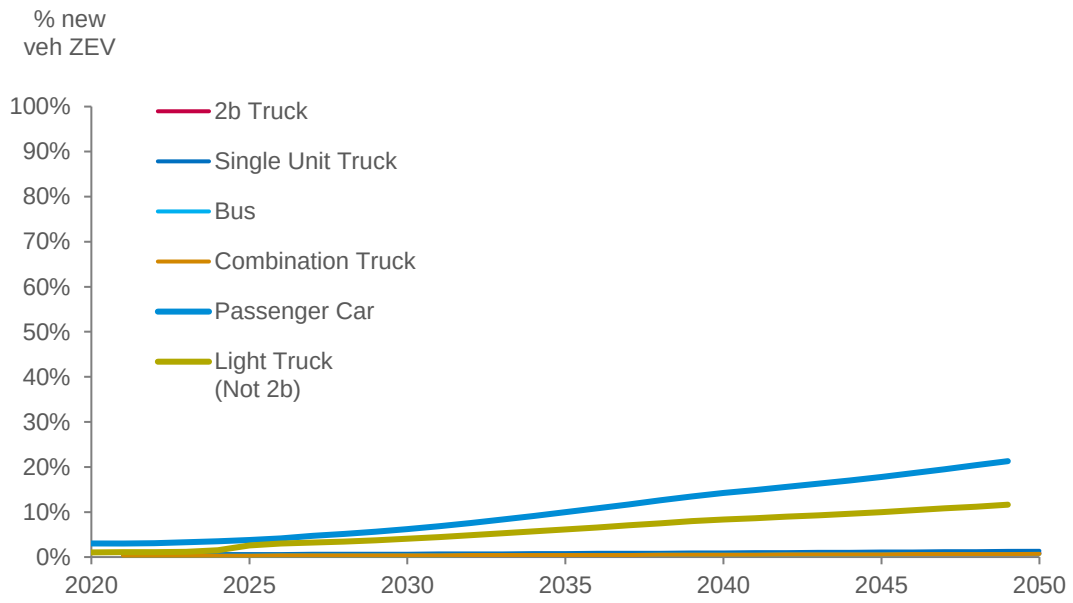
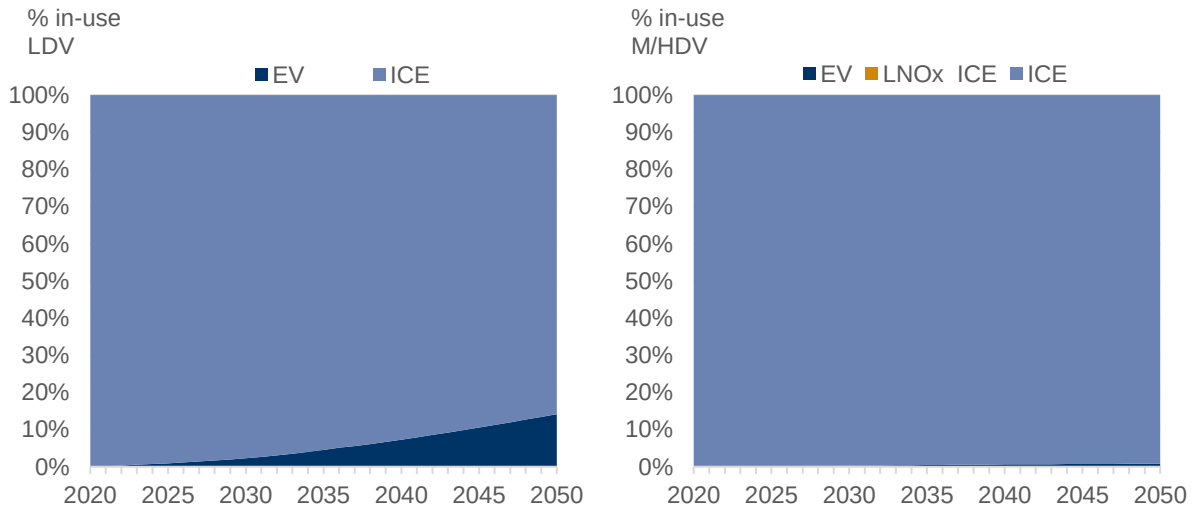


Figure 4A. Percentage of EVs in-Use (Baseline Scenario) LDV (left) and M/HDVs (right)



Under the Medium Scenario, by 2050 in-use EVs reach 66.2 percent of total LDVs. For M/HDVs, in-use EVs reach 58.9 percent and the remainder of vehicles in-use are LNOx vehicles (41.1 percent of total M/HDVs in 2050). See **Figure 5A** for the percentage of new EV sales under the Medium Scenario and **Figure 6A** for the percentage of in-use EVs for LDVs and in-use EVs and Low NOx Vehicles for

M/HDVs. Compared to the Baseline Scenario, EV sales and in-use percentages are much higher by 2050.

Figure 5A. Percentage of New EV Sales (Medium Scenario)

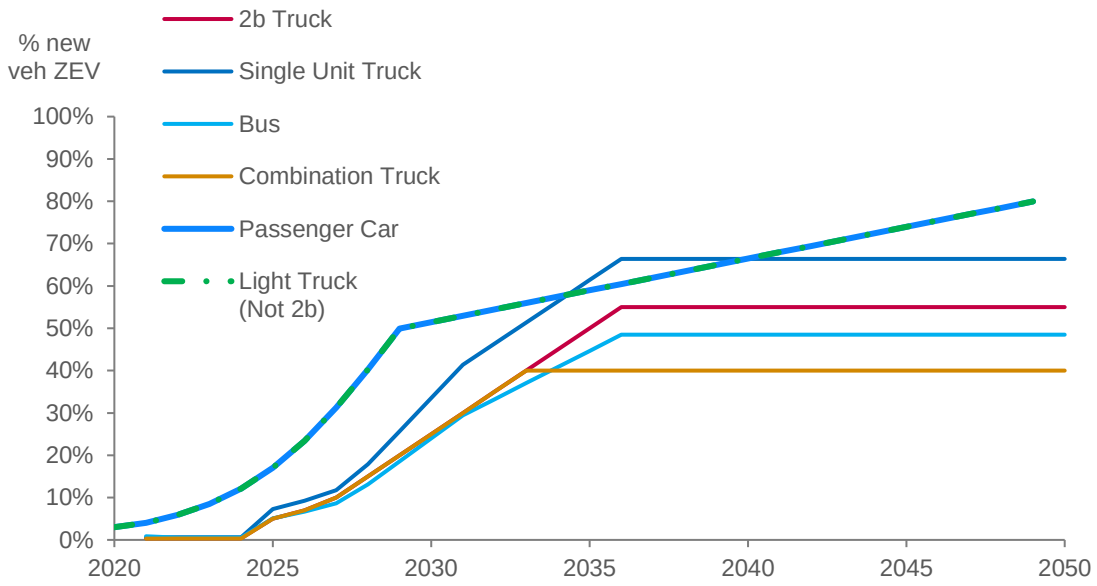
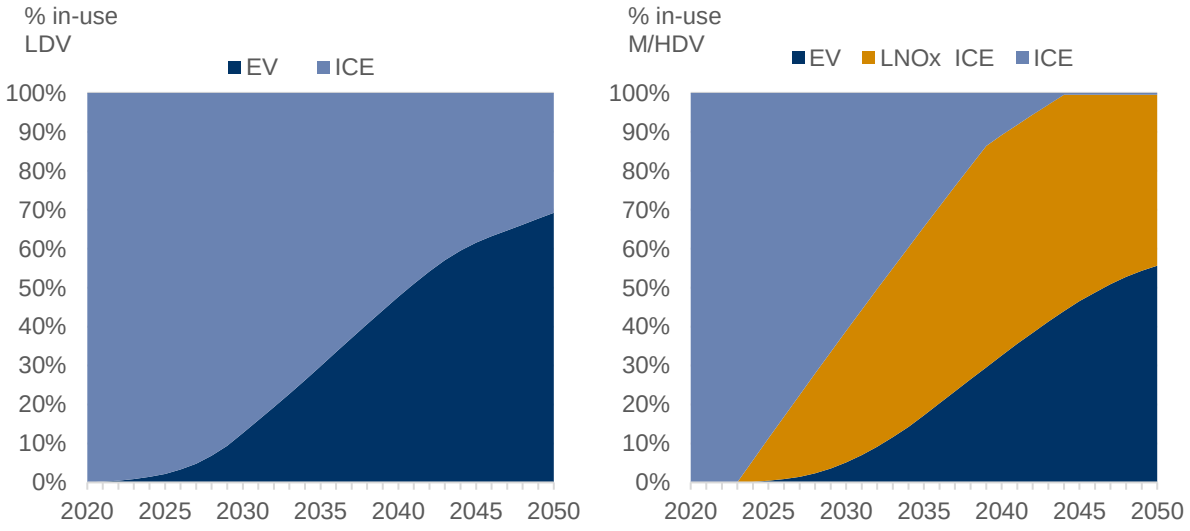


Figure 6A. Percentage of EVs in-Use (Medium Scenario) LDV (left) and M/HDVs (right)



In the High and High (Clean Grid) Scenarios in 2050, in-use EVs reach 95.8 percent of total LDVs and for M/HDVs in-use EVs reach 93.2 percent, with the remainder made up of in-use Low NOx Vehicles (6.8 percent of total M/HDVs in 2050). The High and High (Clean Grid) Scenarios have the same assumed EV sales trajectories and percentage of in-use EVs, the only difference is that the High (Clean Grid) Scenario uses a more decarbonized grid. See **Figure 7A** to see the percentage of new EV sales and see **Figure 8A** for the percentage of in-use EVs for LDVs and in-use EVs and LNOx vehicles for M/HDVs. Under the

High and High (Clean Grid) Scenarios, in-use EVs reach almost 100 percent by 2050 for both LDVs and M/HDVs.

Figure 7A. Percentage of New EV Sales (High/High [Clean Grid] Scenarios)

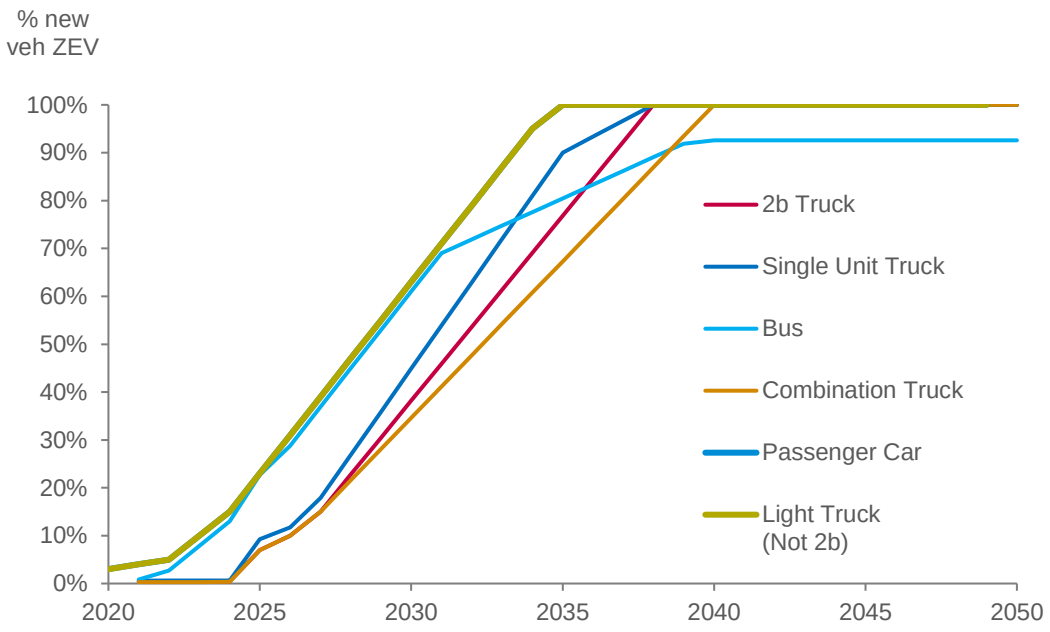
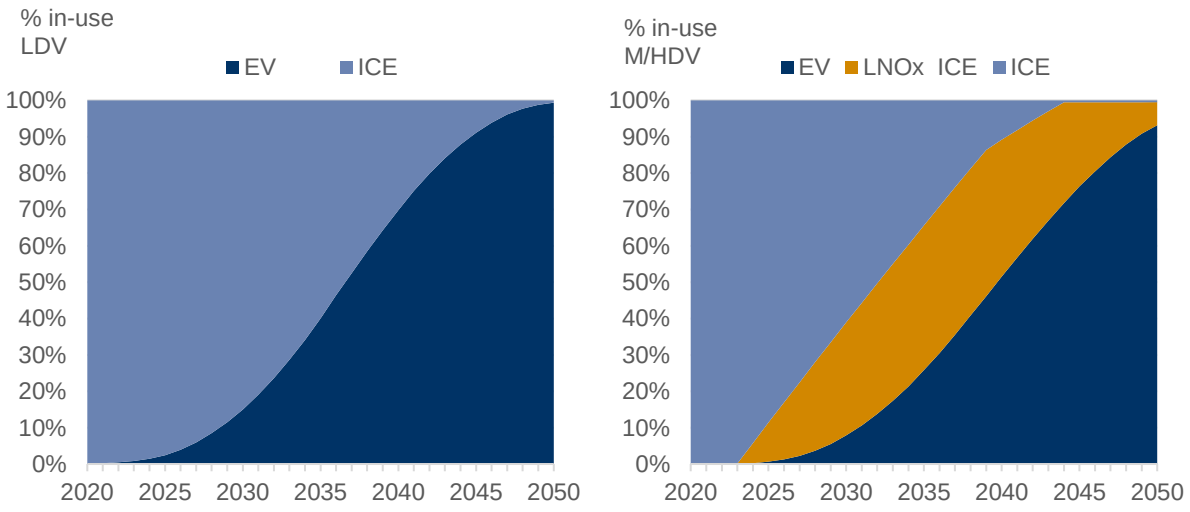


Figure 8A. Percentage of in-Use EVs (High/High [Clean Grid]) LDVs (left) and M/HDVs (right)



6.4 Public Health and the Environment

The modeled scenarios produce significant reductions in NOx, PM, and GHG emissions from light-, medium-, and heavy-duty vehicle electrification, even after accounting for the emissions from producing the incremental electricity needed to power EVs. NOx and PM reductions will improve local air quality, particularly in urban areas, resulting in public health benefits from reduced mortality and hospital visits.

6.4.1 Air Quality Impacts

An additional benefit of transitioning from ICE vehicles to EVs is improved air quality for all North Carolina residents and improved health as a result. The model takes a lifecycle view of emissions considering upstream emissions from petroleum production (well-to-tank), tailpipe emissions (tank-to-wheel), and emissions that will result from the increased electricity generation required to power EVs (well-to-wheel). The generation mixes discussed above were utilized to calculate the emissions from EV charging electricity. Estimated emissions from EV charging, along with upstream emissions for gasoline, diesel fuel, and natural gas are based on Argonne National Laboratories' Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) Model outputs.

The model framework quantifies the reductions in two criteria pollutants known to have adverse impacts on human health: NOx and PM **Figure 9A** and **Figure 10A** show estimated annual on-road vehicle related NOx and PM emissions, respectively. The baseline shown (gray line) is a scenario with very little EV adoption and continued use of gasoline and diesel vehicles in North Carolina. The reductions in PM and NOx under the Baseline Scenario are caused by improved emissions standards for vehicles and the small adoption of EVs. For both pollutants, the baseline trajectory levels off in later years, due to projected increases in vehicle miles traveled (VMT) in North Carolina, offsetting reductions from vehicles turning over to more stringent emissions regulations. The Baseline has an assumed reduction of 55 percent for NOx and 48 percent for PM.

Figure 9A. Estimated On-Road Vehicle Related NOx Emissions

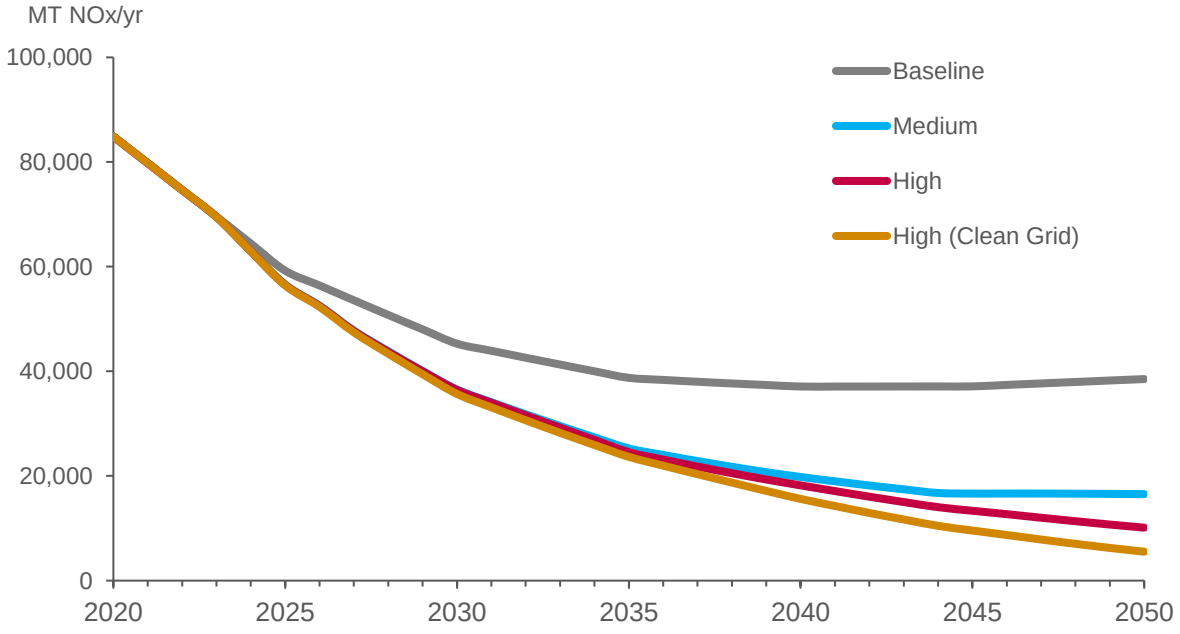
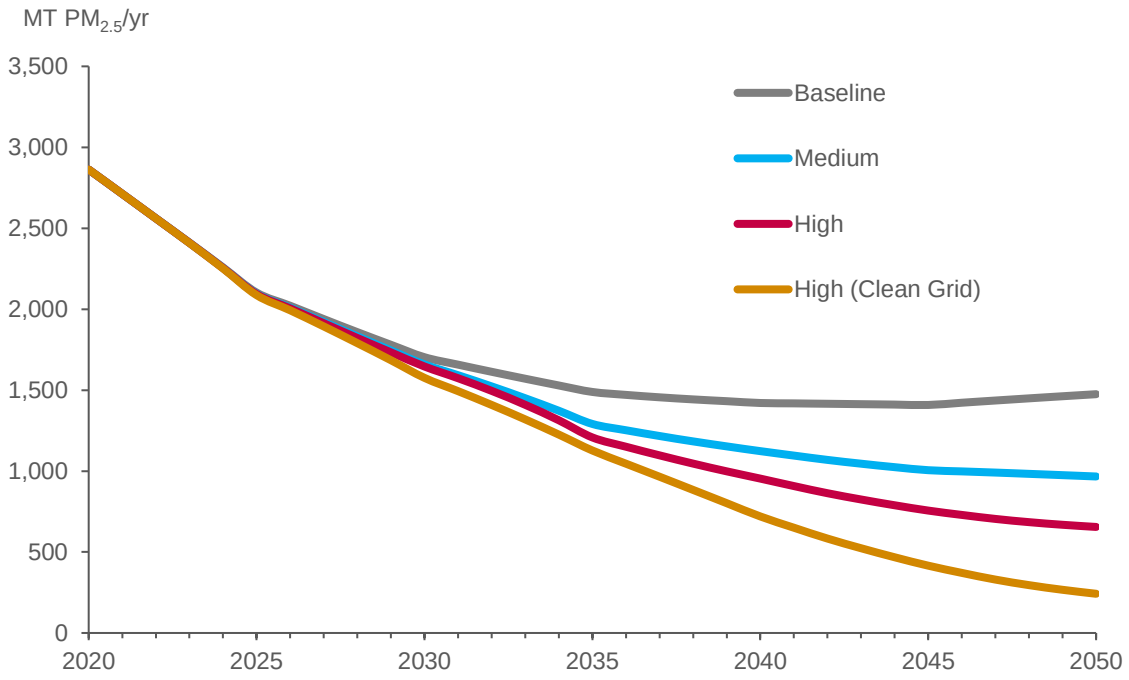


Figure 10A. Estimated On-Road Vehicle Related PM Emissions



Compared to the Baseline, the Medium Scenario is estimated to decrease NOx by 2 percent and PM by 18 percent in 2050. This represents a cumulative reduction in emissions between 2020 to 2050 of 379,638 metric tons (MT) for NOx and 6,230 MT of PM. Compared to the Baseline, by 2050 the High Scenario will reduce emissions for NOx and PM by an estimated 19 percent and 29 percent respectively representing a cumulative reduction of 426,892 MT of NOx and 9,762 MT of PM. Finally, for the High (Clean Grid) Scenario, compared to the Baseline, emissions for NOx and PM are expected to fall 31 percent and 43 percent respectively by 2050 with cumulative reductions of 480,922 MT of NOx and 14,646 MT of PM.

6.4.2 Public Health Benefits

The reduced emissions discussed above could have positive health impacts for North Carolina residents due to breathing fewer pollutants. Estimated public health impacts include reductions in premature mortality, fewer hospital admissions, and emergency room visits for asthma. There could also be reduced cases of acute bronchitis, exacerbated asthma, and other respiratory symptoms, and fewer restricted activity days and lost workdays. Cumulative estimated reductions in these health outcomes in North Carolina under the modeled scenarios are shown in **Table 1A**; these benefits were estimated using EPA's CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool. The monetized value of cumulative public health benefits between 2020 and 2050 totals $9 billion, $11.8 billion, and $12.5 billion for the Medium, High, and High (Clean Grid) Scenarios, respectively.

Table 1A. Cumulative Estimated Reductions in Health Outcomes Under Modeled Scenarios

Policy Scenario*	Cum. Reduction (MT)		Cumulative Reduced Incidents				Monetized Value (2020$ bil)
	NOx	PM	Mortality	Hospital**	Asthma-Related Emer. Room	Restricted Activity Days***	
Medium	379,638	6,230	773	493	277	463,271	$9.0
High	426,892	9,762	1,007	640	359	603,369	$11.8
High (Clean Grid)	480,922	14,646	1,070	679	379	636,083	$12.5

** Compared to the Baseline Scenario*

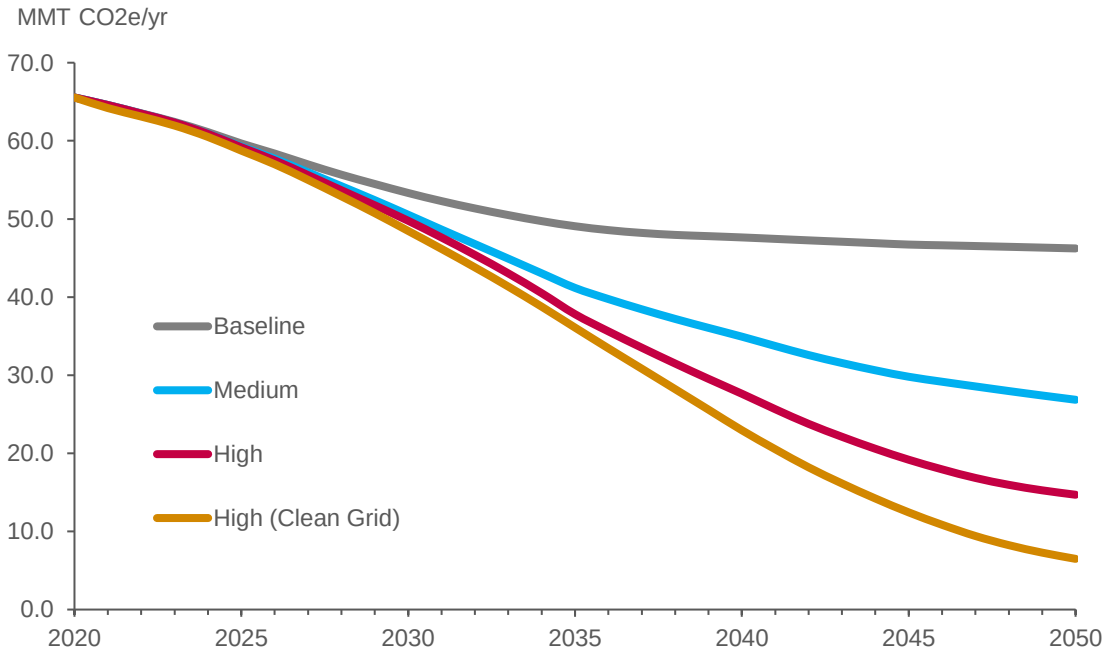
***Hospital visits include respiratory-related hospitalizations, asthma-related hospitalizations, hospitalizations related to chronic lung disease, and cardiovascular-related hospitalizations*

****Restricted activity days are days where activity is limited, but not severely restricted, for example missing work*

6.4.3 Climate Benefits

The projected annual GHG emissions (million metric tons carbon-dioxide equivalent, MMT CO2-e) from the North Carolina fleet under each EV penetration scenario are shown in **Figure 11A**. The figure also illustrates the Baseline trajectory (gray line). Reductions associated with each EV scenario are compared against this Baseline.

Figure 11A. Estimated On-Road Vehicle Related GHG Emissions



GHG emissions from on-road vehicles in North Carolina were approximately 65.5 MMT in 2020. Under the Baseline trajectory, emissions are projected to fall to approximately 46.2 MMT by 2050 due to turnover in the fleet to more efficient ICE vehicles as well as a small portion of EVs being sold. Compared to Baseline emissions in 2050, annual GHG emissions are modeled to be reduced by approximately 19.4

MMT under the Medium Scenario, 31.5 MMT under the High Scenario, and 39.7 MMT under the High (Clean Grid) Scenario.

Climate benefits are monetized using the social cost of GHG values with a 3 percent discount rate reported by the Interagency Working Group on Social Cost of Carbon, Methane, and Nitrous Oxide.[34] These values represent potential cost savings from avoiding the negative effects of climate change, if GHG emissions are reduced enough to keep long-term warming below two degrees Celsius from pre-industrial levels. These impacts include the danger sea level rise poses to coastal communities, the damage inflicted by stronger tropical cyclones, the health impacts of extreme summer temperatures, and many other consequences of climate change. Modeling concluded that the cumulative monetized value of GHG emission reductions could reach over $39 billion by 2050 for the High (Clean Grid) Scenario.

Table 2A summarizes the modeled monetized "social value" of cumulative GHG reductions (2020-2050) that could result from decarbonization efforts in North Carolina. Modeling concluded that the cumulative monetized value of GHG emission reductions could reach over $39 billion by 2050 for the High (Clean Grid) Scenario.

Table 2A. Cumulative GHG Reductions and Monetized Benefits

Policy Scenario*	Cumulative Reductions (mil MT CO2e) by 2050	Cumulative Monetized Value (2020$ bil) of Reductions by 2050
Medium	260.2	$20.0
High	407.9	$31.5
High (Clean Grid)	507.2	$39.2

** Compared to the Baseline Scenario*

6.5 Economic Impacts

This section summarizes projected economic impacts of the modeled scenarios, including changes in annual operating costs, impacts to North Carolina electric utilities and their customers, costs and benefits to EV owners, required public and private investment in electric vehicle charging infrastructure to support the electric fleet under each scenario, and net overall societal benefits.

6.5.1 Vehicle Price

Current LDVs are more expensive to purchase than similarly sized gasoline vehicles, but they are eligible for various government purchase incentives, including up to a $7,500 federal tax credit. These incentives are important to spur an early market but, as described below, EVs are projected to provide a lower total cost of ownership than ICE vehicles in North Carolina by 2025, even without government purchase subsidies. For M/HDVs, current vehicle offerings remain low, but many new models are being announced. Given that this market is in its infancy, incremental costs for these vehicles will initially be high, but like the LDV market, these costs are projected to fall as technology improves and increased demand spreads out costs across the country.

The largest contributor to incremental purchase costs for EVs compared to ICE vehicles is the cost of batteries. Looking at LDV offerings, battery costs for plug-in vehicles have fallen from over $1,000/kWh to less than $300/kWh in the last six years; many analysts and auto companies project that battery prices will continue to fall – to below $110/kWh by 2025, and below $75/kWh by 2030. As battery prices fall, the price of a battery electric vehicle (BEV) is expected to fall below that of a gasoline vehicle. Some studies have indicated the purchase price of EVs will match ICE vehicles within the decade, consistent with these studies, the model shows: LDVs with a range of 200 miles become cheaper than ICE vehicles in 2026

while BEVs with a 300-mile become cheaper than ICE vehicles in 2028. Because plug-in hybrid vehicles (PHEVs) require both a battery system, as well as a gasoline engine/generator combo, PHEV prices never fall below traditional ICE vehicles in the model. For M/HDVs, total lifetime ownership costs begin higher than ICE vehicles but will start providing savings for the vehicle owner around prior to 2030 and beyond, when incremental purchase costs are outweighed by the fuel and maintenance savings of EVs.

6.5.2 Changes in Fuel Use

Increased ownership of EVs will inherently cause an increase in electricity usage for EV owners who charge at home or at a vehicle depot. An LDV owner will see a negative net fuel cost (a savings in fuel costs) over the lifetime of the vehicle of about $5,000 because the increased costs of electricity are offset by savings from reduced gasoline purchases. A M/HDV owner will see a savings in fuel costs of about $29,000 over the lifetime of the vehicle.

6.5.3 Costs and Benefits to Vehicle Owners

As mentioned previously, ownership of EVs will cause an increase in electricity usage when vehicles charge at home, in the case of LDVs, or their depot for M/HDVs. However, this increase is more than offset by savings from reduced fossil fuel purchases. Over their lifetimes, a light-duty EV owner could save approximately $4,000 in net fuel savings and an electric M/HDV owner could save over $20,000 in fuel.

The model estimates the impact of EV ownership by assessing the differences in fuel, maintenance, charger, and vehicle cost between an EV and an ICE vehicle. **Figure 12A** and **Figure 13A** show the average EV lifecycle costs for vehicles purchased in model year 2025, 2030, 2035, and 2040. For LDVs, the full lifetime of the vehicle is assumed to be 16 years and for a M/HDV, the lifetime is assumed to be 21 years. The fuel and maintenance costs are discounted at 4 percent to calculate their present value.

EVs require less vehicle maintenance than traditional gasoline and diesel vehicles due to their simpler construction and fewer moving parts. Over the lifetime of the vehicle, this translates into $2,000 worth of savings for the average LDV and more than $14,000 for an average M/HDV.

EV owners require additional infrastructure to facilitate charging their vehicles whether they install charging equipment at their homes or depots or utilize public charging stations. The cost of all of the charging equipment used by LDVs and M/HDVs is included in the analysis shown in **Figure 12A** and **Figure 13A**. Even though EV owners will not personally be paying for public charging infrastructure, the cost of charging at a public charger is expected to have a premium added to the cost of electricity.

Figure 12A. Light-Duty Vehicle Net Lifecycle Costs

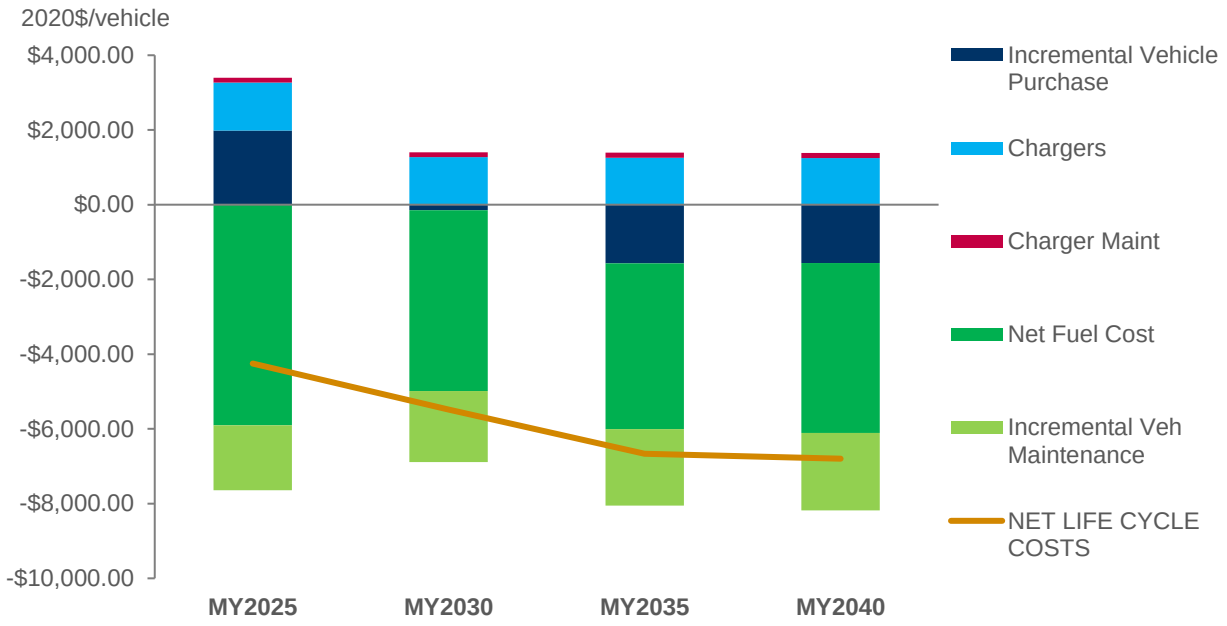
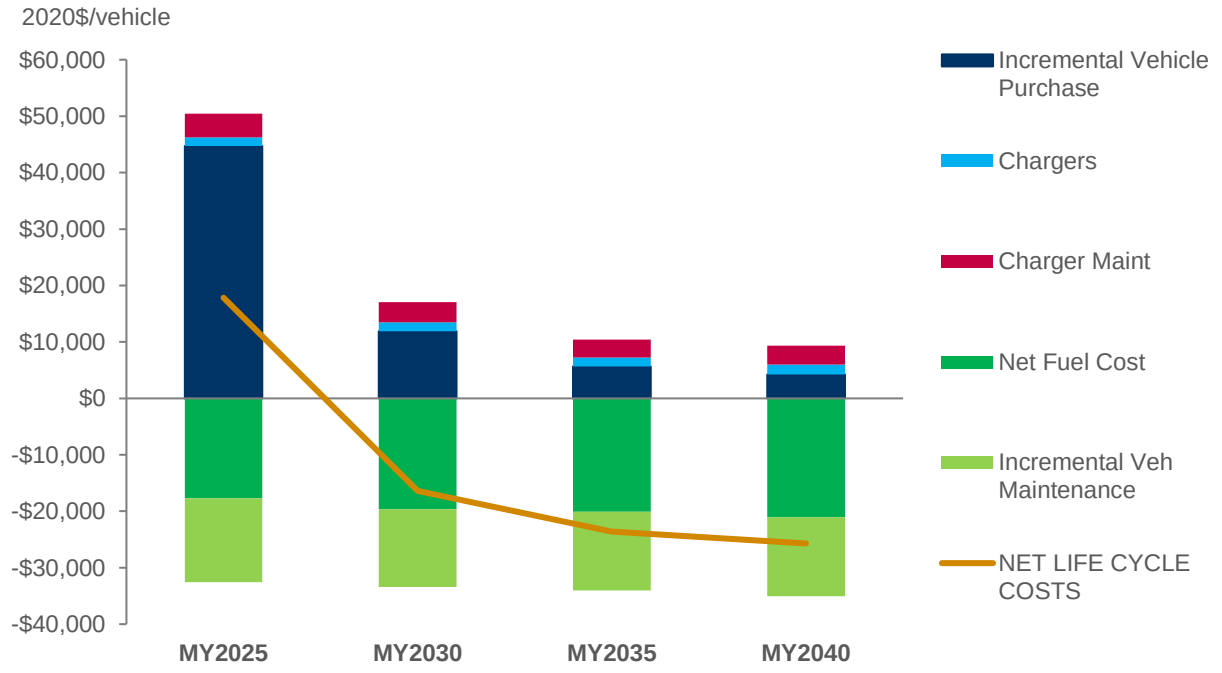


Figure 13A. Medium- and Heavy-Duty Vehicle Net Lifecycle Costs



6.5.4 Electric Utility Impacts

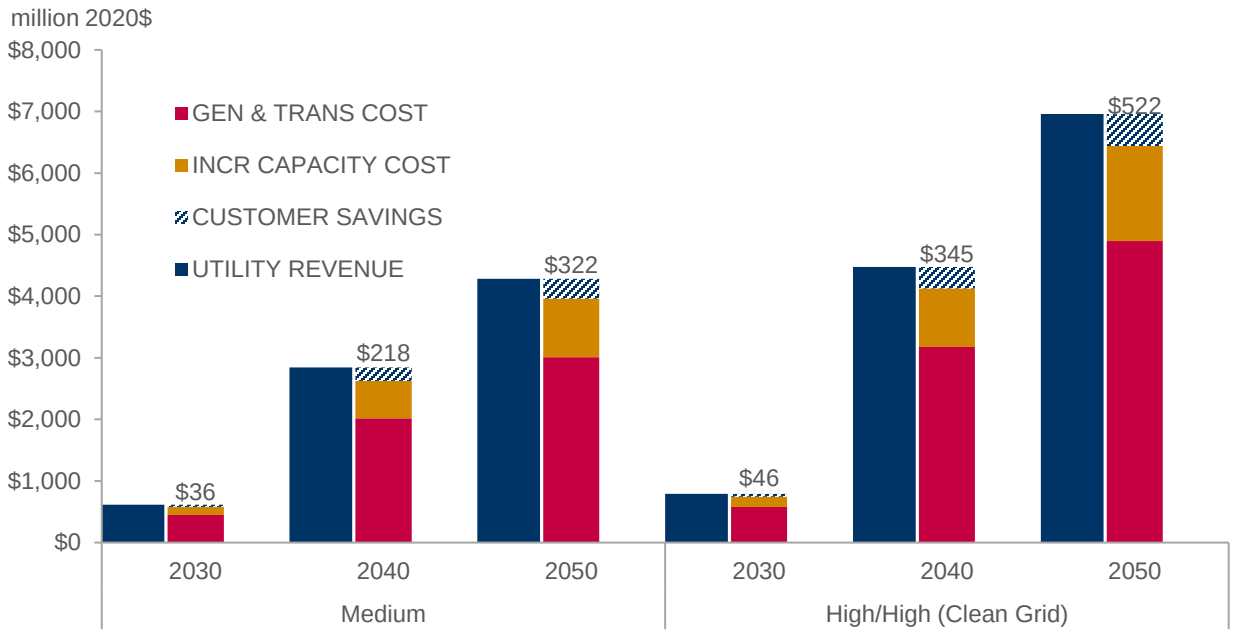
To estimate the net impact of EV saturation on utility costs, and therefore potential savings to utility customers, the model considers the additional revenue from increased electricity sales, the cost of generation and transmission of that additional electricity, and the cost of building additional capacity into the electric system due to the additional load caused by EVs. To calculate the revenue from incremental

vehicle charging, current residential and commercial electricity rates (dollars per kilowatt-hour) are annually adjusted through 2050 based on the EIA Annual Energy Outlook (AEO) projection for electricity prices in the South Atlantic region. These rates are multiplied by the incremental charging energy (kilowatt-hours) for the projected EV vehicles under each scenario to obtain the utility revenue.

To calculate the generation and transmission costs, AEO's regional electricity module assumptions on the portion of rates attributable to generation and transmission are applied to the revenue calculated above. For the increased capacity cost, commercial demand rates (dollars per megawatt of demand) for North Carolina are used as a proxy for incremental capacity since the intent behind demand-based billing is for the utility to recoup costs associated with increased levels of peak demand, requiring additional capacity be added to the system. The demand rates are adjusted in the same manner as the electricity rates.*

Figure 14A shows modeled annual utility revenue in dark blue. The different elements of incremental annual cost that utilities would incur to purchase and deliver additional electricity to support EV charging are shown in red (volumetric generation and transmission costs)† and orange (costs required to upgrade or expand distribution system capacity). Capacity upgrade costs are costs incurred by the utility to upgrade their distribution infrastructure to handle the increased peak load imposed by EV charging.

Figure 14A. Net Impact of EV Saturation on Utility Costs



6.5.5 Impact on Rates & Customer Benefits

Utility customers could see savings, as high as $522 million by 2050 under the High and High (Clean Grid) Scenarios. The modeling finds that increased EV saturation with a more efficient use of the grid (i.e., utilizing the available capacity during off-peak hours) has the potential to exceed the total cost of

* Note that this approach means that overall incremental capacity needs are measured, not feeder-by-feeder needs. This model does not account for locational distribution of EVs which could otherwise increase or decrease costs (e.g., ten EVs on a feeder with excess capacity may not trigger capacity upgrades, while one EV on an overloaded feeder could require capacity upgrades). However, on a statewide average basis this approach estimates total needs. Furthermore, this model does not consider non-wires alternatives to distribution capacity upgrades, such as battery storage. These solutions could help to lower long-term costs and therefore costs here may be overestimated.

† For simplicity, it is assumed that all electric vehicle owners are part of a utilities' standard service offering (i.e., energy generation plus delivery of the energy is carried out by a single entity)

increased generation and infrastructure needed to serve those EVs. If these utility savings were to flow to utility customers, high levels of EV saturation may put downward pressure on rates and lead to volumetric (dollars per kilowatt-hour) savings. However, for North Carolina residents who own EVs and charge their vehicles at home, their electric bill will likely increase due to their higher level of electricity usage. This electricity cost increase is offset by a decrease associated with fuel savings as is discussed in more depth above.

Other impacts on the electric grid including transition to a low carbon emitting generation mix may have costs associated with it that are not included in this modeling.

6.5.6 Required Public and Private Investments

6.5.6.1 Managed Charging

The model allows for managing two types of LDV charging: at home evening charging and daytime workplace charging. The inputs for LDV managed charging include the percent of participating vehicles, the timeframe for limiting charging, and the timeframe in which charging is shifted. Given the focus of EV impacts on utilities, it is central to understand the effect of managed charging on the overall grid.

The model also considers charging for M/HDVs. It assumes that much of the management of charging for M/HDV is conducted by fleet owners incentivized by keeping demand charges low. This results in the majority of M/HDV charging taking place overnight.

Home LDV Charging

For many grids, including the summer grid in North Carolina, the peak in electricity demand corresponds with when people traditionally arrive home from work in the early evening hours. If all EV owners were to begin charging their vehicles when they arrived home, the peak in EV charging load would be layered on top of the baseline system peak. This could substantially increase the required peak capacity of the electric grid, necessitate additional investment to address these system needs, and make the grid less efficient. However, if the period of charging is shifting to off-peak hours, such as nighttime hours, when baseline system demand is lower, EVs have the potential to make the electric grid more efficient.

These penetration scenarios assume that home managed charging shifts 70 percent of EVs arriving home after 2 p.m. to delay charging their vehicles until after 9 p.m., rather than beginning charging immediately upon arrival at home. This managed charging scenario assumes that charging will be evenly spaced out during the period of 9 p.m. to 5 a.m.

Workplace Charging

The modeling assumes that a portion of public workplace charging is managed. Without managed charging, for EVs that charge using workplace chargers, a similar spike in demand would be expected at the beginning of the workday. The model assumes that workplace managed charging has 70 percent of EVs utilizing workplace L2 charging between 5 a.m. and 3 p.m. to spread out the charge evenly until 3 p.m.

M/HDV Charging

For M/HDVs, managed charging looks quite different from LDV charging since most M/HDVs are assumed to charge overnight at their depot and they are typically used for local or regional operations in which they begin and end the day at the same location. Since most vehicles are assumed to charge overnight, they are already charging during off-peak hours.

Combination trucks are treated differently than the rest of M/HDVs. Approximately 30 percent of these vehicles are used for local/regional hauling and can use overnight depot charging. The remainder are used primarily for long-haul freight operations, which do not return to the same location every night and can travel 500 miles or more per day. As such, these vehicles will need to use a shared, public network of higher-power chargers (500+ kW/port) and are assumed to plug in as needed to maintain state of charge.

Managed Charging Over Time

The model does not vary the managed charging scenarios across years and does not allow for changes in the load curve that drives the managed charging scheme. As more renewables are added to the North Carolina generation mix, patterns of electricity generation and availability may change. A high proportion of solar energy might make shifting vehicles to nighttime hours less useful, as vehicles need to be shifted to early afternoon hours when solar electricity generation is at its highest. It is important for policies and programs to be responsive to allow managed charging to meet changes in load curve and increase the efficiency of the grid.

6.5.6.2 Required Charging Infrastructure

Types of Chargers

The model assumes that home LDV chargers will be in the form of Level 1 (standard 120V outlets) as well as Level 2 (240V). These chargers typically require 2-10 kW per port, depending on the voltage used (Level 1 or 2) and the amperage feeding the charger. Level 2 (L2) chargers are the preferred method of charging for BEVs due to their higher energy output and therefore faster charging speeds. Alternatively, Level 1 (L1) chargers require no additional equipment or installation, but due to their low amperage, can require exorbitant amounts of time to replenish electric vehicle batteries. Due to this, the model only assumes that a portion of PHEVs will utilize these L1 chargers. For L2 chargers, since the voltage needs to be increased above standard household outlet voltage (120V), equipment needs to be purchased and installed by a licensed electrician. For public and workplace charging, LDVs are assumed to use L2 and direct current fast-chargers (DCFC). DCFC charge vehicles more quickly (at rates of 50kW or above) but also require more infrastructure investment and maintenance.

For M/HDVs, the model includes depot chargers that will require higher power ratings than LDV L2 chargers, in the range of 10-50 kW per port depending on the vehicle type. Modeled public chargers will range from 150 kW public chargers to support single-unit freight trucks, while the higher-capacity 500 kW public chargers are needed mostly for combination trucks. **Table 3A** below summarizes the number of cumulative charge ports needed by charger type as well as the annual investment needed for each modeled scenario.

Table 3A. Estimated Number of Chargers and Investments Needed Under Each Scenario

Metric		Medium		High/High (Clean Grid)	
		2030	2050	2030	2050
Cumulative Charge Ports	Home	870,517	5,433,077	1,069,867	8,401,348
	Depot	31,029	392,486	48,417	657,530
	Public L2	9,926	61,950	12,199	95,796
	Public 150 kW	3,220	22,649	4,075	35,307
	Public 500 kW	324	3,672	471	8,026
Investment per Year, 2020$ (million)	Home	$295	$466	$328	$621
	Depot	$53	$111	$79	$201
	Public	$128	$201	$154	$339

Number of Chargers Calculation

To calculate the number of chargers required, the model first determines the percent of EVs charged at home/depot as opposed to in public as well as what type of charger they will use. A distinction is made in assumptions between single-family homes and multi-unit dwellings with the model assuming 27 percent of North Carolinians live in multi-unit dwellings. 90 percent of PHEV and BEV owners living in single family homes are assumed to charge at home while only 25 percent of PHEV and 60 percent of BEV owners living in multi-unit dwellings are assumed to charge at home. In 2020, home chargers are split between L1 and L2 chargers with 80 percent of PHEV and 25 percent of BEV owners expected to use home L1 chargers with the remainder using home L2 chargers. This distribution of vehicles and chargers is projected to shift after 2030, resulting in less vehicles utilizing L1 chargers (only 50 percent of PHEVs and 0 percent for BEVs). The remainder of BEVs and PHEVs are assumed to use home L2 chargers. Public LDV chargers for all years in the modeling timeframe are split between L2 and DCFC with 100 percent of PHEV and 40 percent of BEV owners expected to use public L2 chargers and the remainder of BEVs using DCFC. The model assumes one charger per vehicle charging at home and uses EVI Pro Lite charger factors to determine the number of public chargers required.

For M/HDVs, the model assumes one charger per vehicle that is charged per night in the depot. Since not all M/HDVs are assumed to be used every day, this means roughly 0.8 chargers per depot charging M/HDV. The number of public chargers required for M/HDVs is calculated assuming between 12 and 22 hours available for vehicles to be charging, the length of time it takes the vehicle to charge, and the percent of vehicles by class using public chargers. **Figure 15A** and **Figure 16A** shows the number of chargers needed, with Home L1, Depot, and Public (L2, 150kW, and 500kW) graphed on the primary axis and with Home L2 chargers graphed on the secondary axis, due to a much larger number of Home L2 chargers predicted to be needed. **Figure 17A** shows the total amount of investments for the predicted numbers of chargers needed for each modeled scenario.

Number and Costs of Chargers

Figure 15A. Predicted Number of Chargers Needed for Modeled Scenarios for Home L1, Depot, and Public Charging*

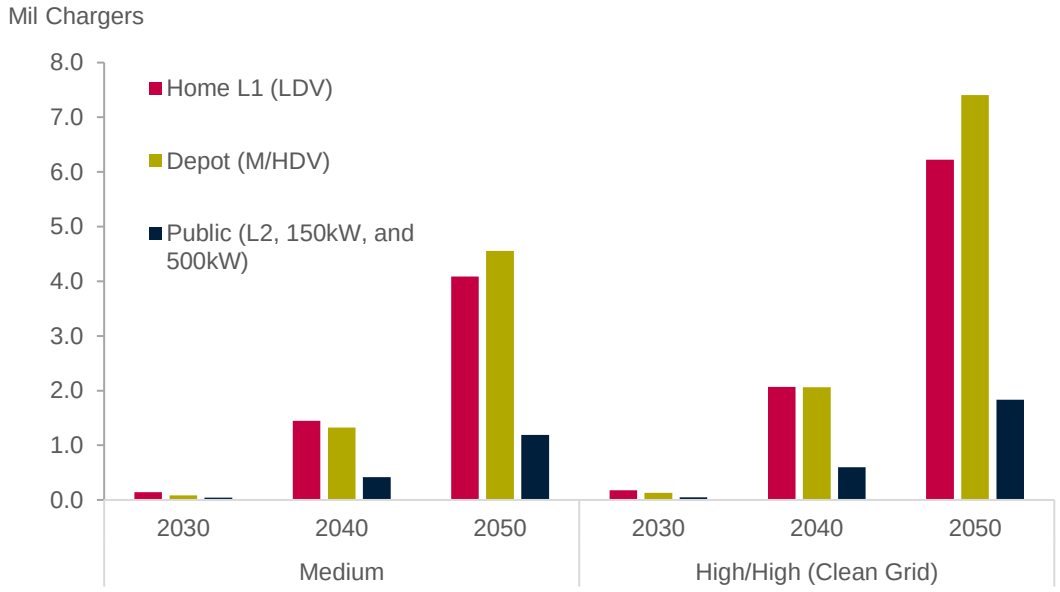
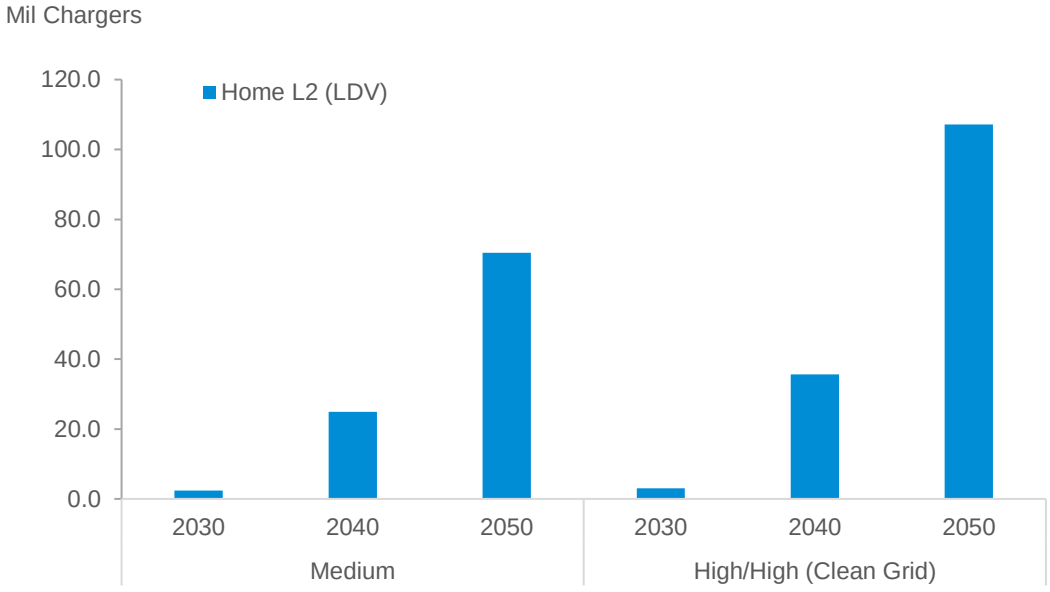


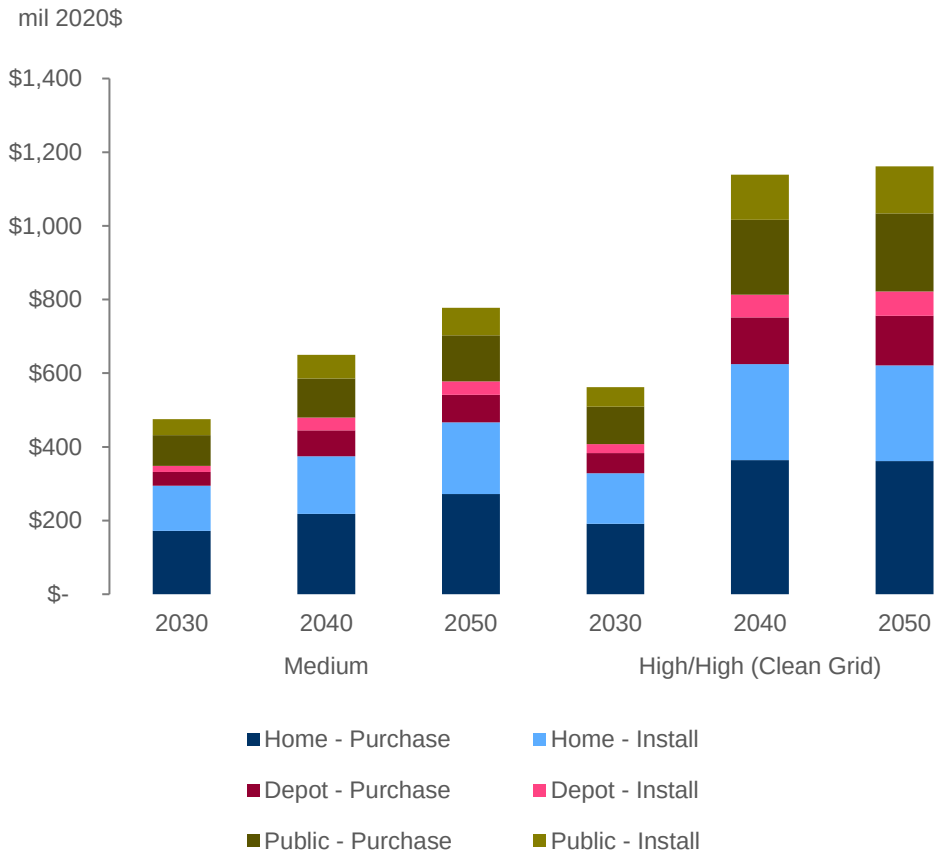
Figure 16A. Predicted Number of Chargers Needed for modeled Scenarios for Home L2†



* The L2 chargers are graphed on a separate chart, due to drastic differences in the vertical axes and a greater demand for L2 chargers.

† The L2 chargers are graphed on a separate chart, due to drastic differences in the vertical axes and a greater demand for L2 chargers.

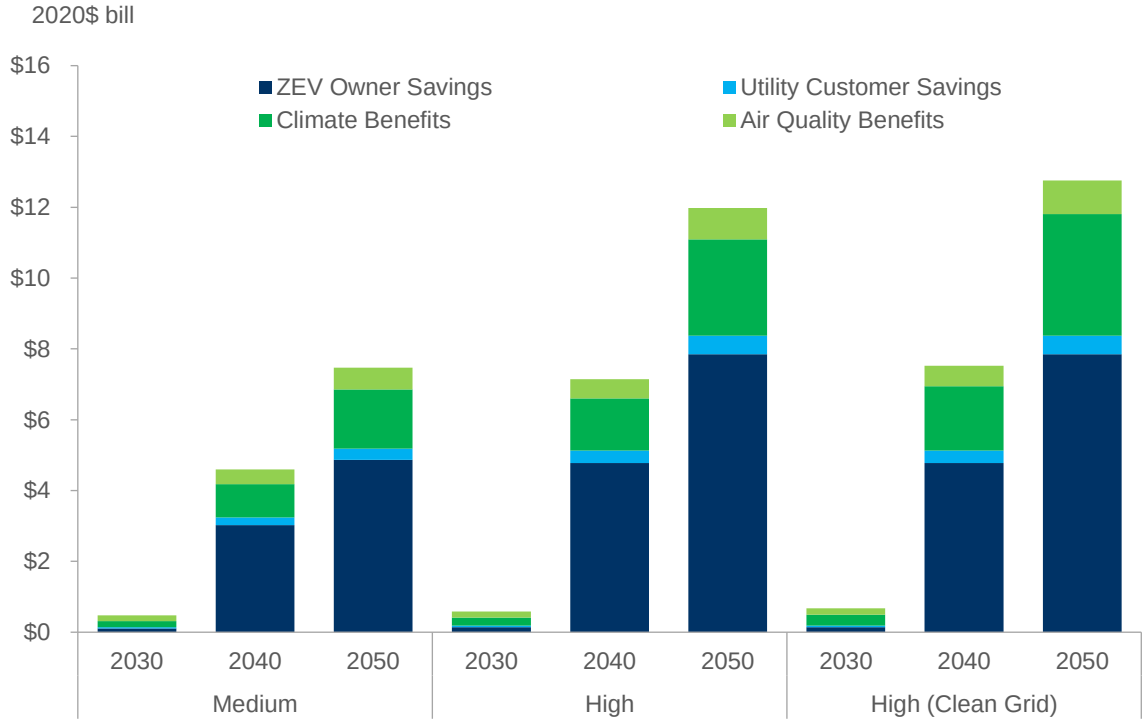
Figure 17A. Cost of EV Charging Infrastructure for Modeled Scenarios Per Year



6.6 Net Societal Benefits

Figure 18A below shows the annual total net societal benefits, combining four classes of costs and benefits discussed above: air quality benefits, climate benefits, utility customer savings, and EV owner savings. EV owner savings (~65 percent) and climate benefits (~25 percent) make up the majority of the societal benefits. By 2050, annual net societal benefits will reach $7.5 billion, $12.0 billion, and $12.8 billion for Scenarios Medium to High (Clean Grid) respectively. The cumulative benefits between 2021 and 2050 amount to $91 billion, $142 billion, and $150 billion for Scenarios Medium to High (Clean Grid) respectively.

Figure 18A. Net Social Benefits from Modeled Scenarios



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