EVOLVING TRANSPORTATION IN NORTH CAROLINA

An Analysis of Emission Reduction Pathways for North Carolina's Transportation Sector

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ACRONYMS & ABBREVIATIONS

AEO .... Annual Energy Outlook
BAU .... Business as Usual
BEV .... Battery Electric Vehicle
CAFE .... Corporate Average Fuel Economy
CDOT .... Connecticut Department of Transportation
CO_2 .... Carbon Dioxide
DCFC .... Direct Current Fast Charging
EIA .... Energy Information Administration
EO80 .... Executive Order 80
EPA .... Environmental Protection Agency
EV .... Electric Vehicle
eVMT .... Electric Vehicle Miles Traveled
EVSE .... Electric Vehicle Supply Equipment
FTA .... Federal Transit Administration
GCO .... Georgia Commute Options
GHG .... Greenhouse Gas
kWh .... Kilowatt-hour
IPCC .... Intergovernmental Panel on Climate Change
LDV .... Light Duty Vehicle
MMT .... Million Metric Ton
MPG .... Miles Per Gallon
MPGe .... Miles Per Gallon Equivalent
MWh .... Megawatt-hour
MY .... Model Year
NASEO .... National Association of State Energy Officials
NCDEQ .... North Carolina Department of Environmental Quality
NCDOA .... North Carolina Department of Administration
NCDOT .... North Carolina Department of Transportation
NHTSA .... National Highway Traffic Safety Administration
NTD .... National Transit Database
PEF .... Plug-In Electric Vehicle
PHEV .... Plug-In Hybrid Electric Vehicle
RUC .... Road Use Charge
TSP .... Traffic Signal Priority
VMT .... Vehicle Miles Traveled
ZEV .... Zero Emission Vehicle

CONTENTS

EXECUTIVE SUMMARY

The transportation sector is the largest source of greenhouse gas (GHG) emissions in the United States and is on track to become the largest source in North Carolina, further contributing to the harmful effects of climate change in the state and around the world. From increased temperatures to more frequent flooding and more devastating tropical storms, the people and the economy of North Carolina are experiencing the result of the developed world's historical reliance on fossil fuels to drive economic growth.

On October 28, 2018, North Carolina Governor Roy Cooper issued an Executive Order (EO80) setting a goal to reduce GHG emissions in North Carolina to 40% below 2005 levels by 2025. In the transportation sector, which accounts for nearly one-third of North Carolina's GHG emissions, emissions reductions are achievable using proven technologies and policies that have been successful in other states. These solutions range from increased adoption of public transit, more electric vehicles, other new forms of mobility, and comprehensive land use strategies and travel demand programs that can reduce the volume of travel across North Carolina.

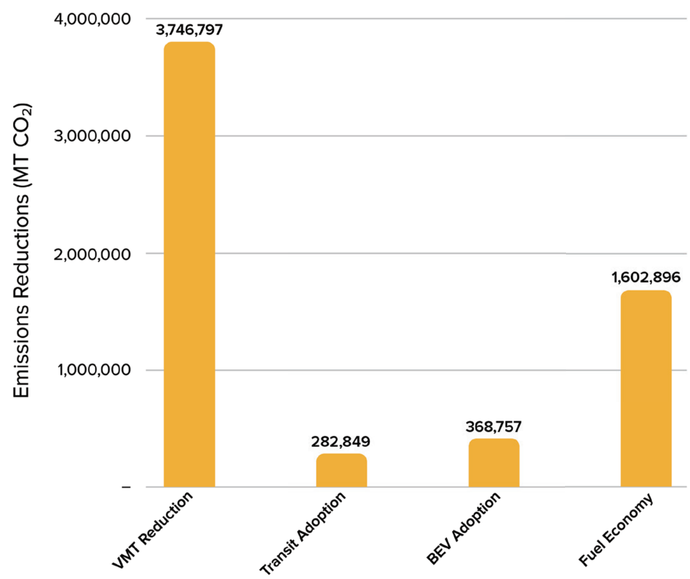
This report identifies four emissions reduction pathways (referred to as scenarios in this report) that demonstrate the diversity of ways to target emissions reductions in North Carolina's transportation sector (see Figure ES-1). For each scenario, we estimated the resulting emissions reductions by 2025 and examined policies that can kickstart and accelerate reductions. We also considered each scenario through the lens of equity to discuss how changes in transportation technology and policy can help create a more equitable and accessible transportation system in North Carolina.

The *2019 North Carolina GHG Inventory Report* projects that transportation emissions will decline to 41 million metric tons of CO_2 (MMT CO_2) by 2025, 25% below 2005 levels. This falls short of the 40% reduction goal outlined in EO80 by 7.9 MMT CO_2. The scenarios evaluated in this analysis have the potential to provide between 283,000 and 3.7 million metric tons of additional CO_2 emission reductions in 2025 from the transportation sector (see Figure ES-2). Several conclusions arise from these findings.

Figure ES-1. Emissions Reduction Scenarios for North Carolina's Transportation Sector

1. **VMT REDUCTION**
   Reduce total vehicle miles travelled (VMT) by light duty vehicles (LDVs) by 10% by 2025.
2. **TRANSIT ADOPTION**
   Shift 1% of LDV travel to public transit by 2025.
3. **BEV ADOPTION**
   Accelerate battery electric vehicle (BEV) adoption to 20% of LDV sales by 2025.
4. **FUEL ECONOMY**
   Achieve a fuel economy of 54.5 miles per gallon (mpg) for all new LDV sales in North Carolina by 2025.

Figure ES-2. Emissions Benefits by Scenario in 2025



There is no silver bullet. This analysis makes clear that achieving the objective of EO80 requires a suite of policies and solutions aimed at delivering transportation emissions reductions. No single policy or mechanism alone can close the gap.

The time to act is now. Given that many of these policies take time to implement and will have a gradual effect, aggressive and immediate action is required to maximize the time available for policies to begin to affect transportation emissions.

Land use planning must evolve as well. The design of our communities and road infrastructure are inseparable from the environmental impact of transportation. Without significant reforms in building codes, zoning laws, land use planning, and highway planning, the effectiveness of any efforts to reduce VMT, encourage transit use, or increase BEV adoption will be limited in their effectiveness.

North Carolina has an opportunity to remake transportation with an equity-first mindset. In the coming years, new technologies and the imperative to lower emissions from transportation will result in dramatic changes in how we get around and how we live, presenting an opportunity to make equitable access to transportation a priority going forward.

1. INTRODUCTION

The transportation sector is the largest source of greenhouse gas (GHG) emissions in the United States and is on track to become the largest source in North Carolina, further contributing to the harmful effects of climate change in the state and around the world. From increased temperatures to more frequent flooding and more devastating tropical storms, the people and the economy of North Carolina are experiencing the result of the developed world's historical reliance on fossil fuels to drive economic growth. Scientific consensus indicates that to avoid the most troubling effects of climate change, the world must reduce emissions global GHG emissions by 45% by 2030 (from 2010 levels) to limit warming to 1.5 degrees Celsius.[1]

Reducing North Carolina's GHG emissions will require the state to make significant commitments, embrace new technologies, and implement new policies and incentives to enable and encourage consumers and businesses in North Carolina to lower their consumption of fossil fuels. In the transportation sector, which accounts for nearly one-third of North Carolina's GHG emissions,[2] emissions reductions are achievable using proven technologies and policies that have delivered emissions reductions in other states. These solutions range from increasing adoption of public transit, electric vehicles (EVs), and other new forms of mobility to reducing the volume of travel and rethinking the design of our urban spaces.

On October 28, 2018, North Carolina Governor Roy Cooper issued an Executive Order (EO80) setting a goal to reduce GHG emissions in North Carolina to 40% below 2005 levels by 2025.[3] Specifically targeting transportation emissions, EO80 also sets a goal of having 80,000 zero emissions vehicles (ZEVs) on the road by 2025. However, EV adoption alone is insufficient to meet the relatively short-term emissions reduction goals outlined in EO80.

This report identifies four emissions reduction pathways (referred to as scenarios in this report) that demonstrate the diversity of ways to target emissions reductions in North Carolina's transportation sector (see Figure ES-1). For each scenario, we estimated the resulting emissions reductions by 2025 and examined policies that can kickstart and accelerate reductions. We also considered each scenario through the lens of equity to discuss how changes in transportation technology and policy can help create a more equitable and accessible transportation system in North Carolina.

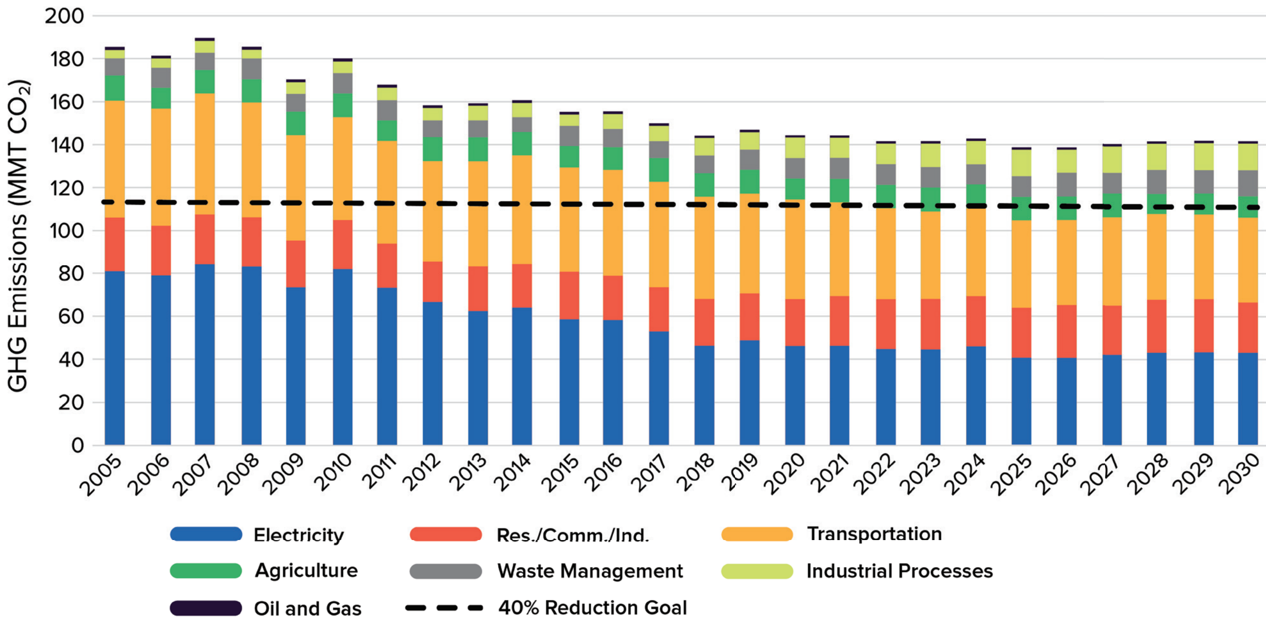
2. ESTABLISHING A BASELINE

GHG Emissions in North Carolina

In January 2019, the North Carolina Department of Environmental Quality (NCDEQ) published an updated inventory of GHG emissions projections with historical emissions from 1990 to the present and projected emissions to 2030. Figure 2 shows emissions by sector from the *North Carolina GHG Inventory*, which represents the business-as-usual (BAU) scenario for the purposes of the quantitative analysis in this report.[4] The dotted horizontal line represents the 40% emissions reduction goal outlined by EO80.

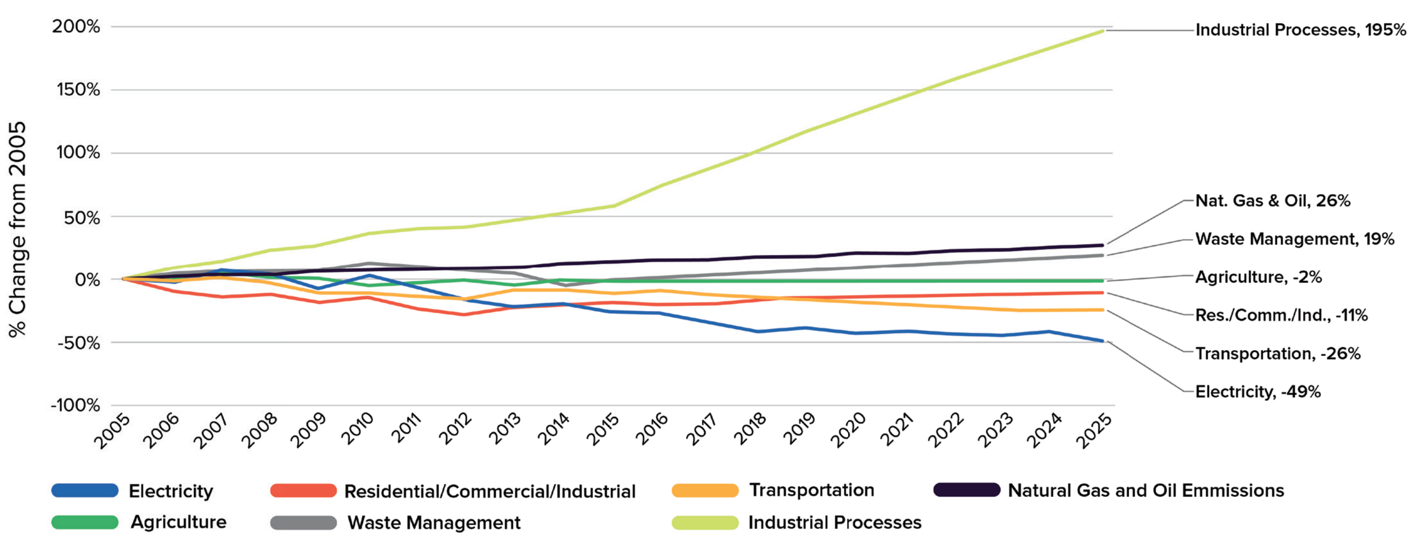
Since 2005, GHG emissions in North Carolina have declined by 22%. However, emissions are projected to remain relatively stable through 2030. By 2025, which is the year of interest for the purposes of this report, GHG emissions are projected to be 25% below 2005 levels, meaning that in the absence of new policy

Figure 2. North Carolina Historical and Projected GHG Emissions by Sector, 2005–2030



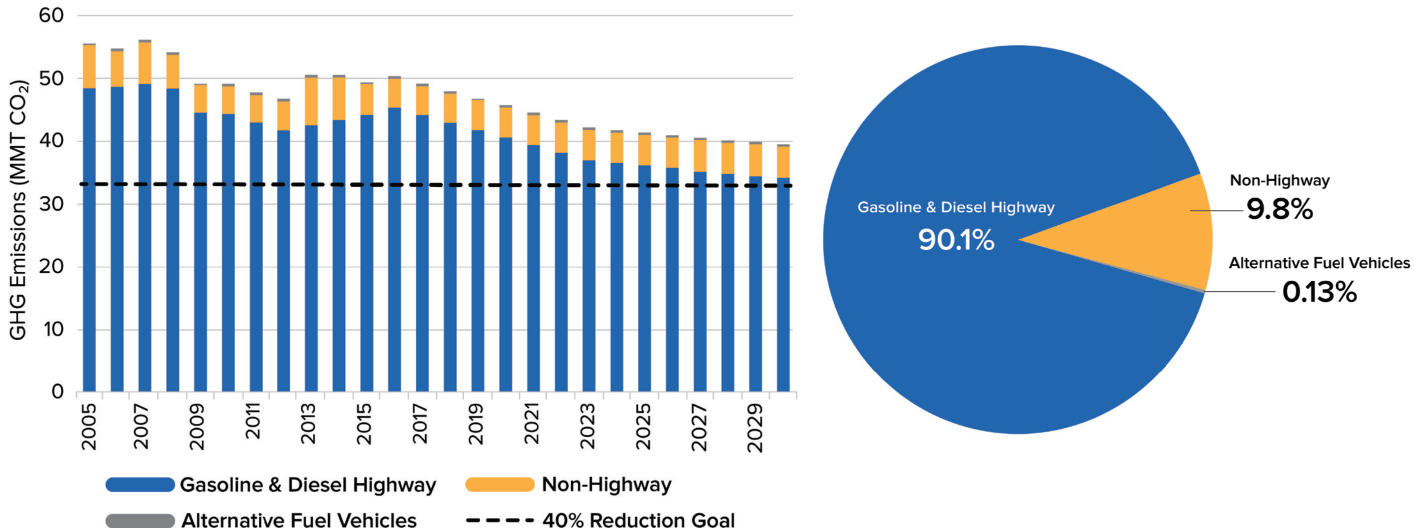
Source: North Carolina Department of Environmental Quality. (2019). North Carolina Greenhouse Gas Inventory (1990-2030). Available at https://files.nc.gov/ncdeq/climate-change/ghg-inventory/GHG-Inventory-Report-FINAL.pdf.

Figure 3. North Carolina GHG Emissions by Sector, Percent Change, 2005-2025



Source: North Carolina Department of Environmental Quality. (2019). North Carolina Greenhouse Gas Inventory (1990-2030). Available at https://files.nc.gov/ncdeq/climate-change/ghg-inventory/GHG-Inventory-Report-FINAL.pdf.

Figure 4. Transportation Sector Emissions by Subsector, 2005–2030



Source: NCDEQ (2019) I Note: Emissions from alternative fuel vehicles are included in both figures but may be too small to see.

initiatives to accelerate GHG emissions reductions, the state will only reduce emissions by an additional 3% between 2018 and 2025. In fact, emissions from some sectors—waste management, industrial processes, and oil and gas—are projected to increase over the next few years. Figure 3 shows the change in GHG emissions by sector between 2005 and 2025, though it is important to note that the electricity and transportation sectors make up 59% of emissions—the other sectors are significantly smaller.

Historically, the electricity sector has been the leader in reducing emissions in North Carolina. The adoption of solar energy, energy efficiency, and some coal-to-gas switching have driven a 42% reduction in electricity sector emissions since 2005. Under current projections, progress is expected to continue, albeit at a slower pace, with the electricity sector reducing emissions by a total of 49% by 2025 compared to 2005 levels. In October 2019, NCDEQ released *North Carolina Clean Energy Plan: Transitioning to a 21st Century Electricity System*, which set a goal of reducing electricity sector emissions by 70% from 2005 levels by 2030, though this goal is not reflected in the GHG inventory projections and would require further measures to be taken to reduce emissions beyond BAU.

Like the electricity sector, the transportation sector has seen emissions decrease steadily since 2005, though to a lesser extent. By 2025, transportation emissions are projected to be 41 MMT CO_2, 26% below 2005 levels (see Figure 4). We estimate that 60% of transportation emissions in North Carolina come from LDVs, which fall into the "Gasoline & Diesel Highway" category in Figure 4.[5] Because they make up the largest share of emissions, driving reductions in LDV emissions is the focus of this analysis.

To achieve EO80's 40% reduction goal in the transportation sector, the state must reduce emissions to 33.1 MMT CO_2 in 2025, an additional 7.9 MMT CO_2 below the BAU projected transportation sector emissions.

To achieve EO80's 40% reduction goal in the transportation sector, the state must reduce emissions to 33.1 MMT CO_2 in 2025, an additional 7.9 MMT CO_2 below the BAU projected transportation sector emissions. As our analyses will show, significant reductions in transportation emissions are achievable within the EO80 time frame but only by aggressively pursuing reductions across many fronts, including by improving fuel economy, promoting alternative fuels, and incentivizing of modal shifts and reductions in personal vehicle travel.

3. SCENARIO ANALYSIS

Summary Methods & Results

To demonstrate the emissions reduction potential in the transportation sector, the study team identified four scenarios and quantified the estimated emissions reductions that would result:

1. VMT Reduction—Reduce total VMT by LDVs by 10% by 2025.
2. Transit Adoption—Shift 1% of LDV travel to public transit by 2025.
3. BEV Adoption—Accelerate BEV adoption to 20% of LDV sales by 2025.
4. Fuel Economy—Achieve a fuel economy of 54.5 mpg for all new LDV sales in North Carolina by 2025.

SUMMARY METHODS

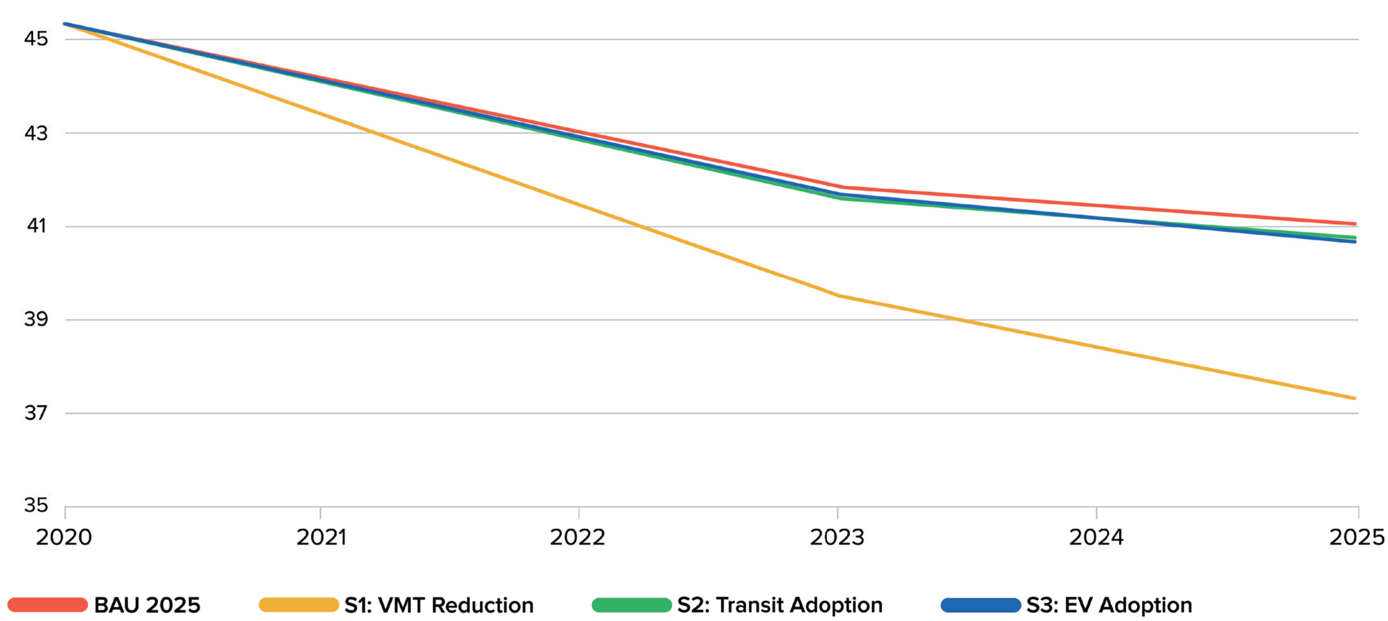
Detailed data sources and methods for each scenario are available in the Appendix of this report, but some important high-level assumptions will aid in the reader's interpretation of the results. First, we considered each scenario independently; for example, when calculating the emissions benefits from EV adoption in the BEV Adoption Scenario, we did not assume that VMT have declined by 10% as modeled in the VMT Reduction Scenario. Additionally, we do not incorporate improved fuel economy from the Fuel Economy Scenario when modeling emissions reductions under other scenarios.

Second, we assumed that each scenario gradually approaches the defined goal in 2025, meaning that we estimated some additional benefits from prior to 2025. We present this information as well, but the focus of this study is primarily on the benefits of achieving the reductions defined by the scenario.

Finally, whenever possible, we used publicly available data to aid in the replicability of the analyses. Each analysis followed the same general approach of defining a BAU or baseline trend from which to measure the incremental benefits of each scenario. When data allowed, we considered projections related to each scenario and assumed that some change is already included in the BAU Scenario.

For example, in the BEV Adoption Scenario, we used existing projections to estimate that BEV adoption will grow to 6.2% market share of new LDV sales in 2025 without any additional intervention. This level of adoption is "baked in" to our BAU Scenario. In the BEV Adoption Scenario, we estimated the benefits associated with increasing BEV adoption from 6.2% to 20% market share of new LDV sales. The difference in emissions between a 6.2% and 20% BEV market share of new LDV sales is our estimate of the benefits that are achievable under this scenario. This approach ensures that we exclude any emissions reductions that are already expected to happen in order to isolate the incremental reductions that must be achieved with new policy interventions.

Figure 5. Comparing Scenario Results with BAU Emissions, 2020–2025 (Note: Scale does not start at zero)



Source: RTI analysis

RESULTS SUMMARY

The results of our study show that taking steps toward reducing VMT has the largest impact on transportation emissions (VMT Reduction Scenario), followed by successfully reaching federal fuel economy improvement targets (Increased Fuel Economy Scenario). See Table 1 for estimated results by scenario in metric tons. Table 1 also presents results as a percentage of 2025 BAU transportation sector emissions and as a percentage of the gap between 2025 BAU emissions and the 40% reduction goal laid out in EO80.

Reducing VMT has the largest impact on transportation emissions...

Sections 4 through 8 discuss each scenario in more detail. Figure 5 shows the resulting emissions projections for the transportation sector under each scenario.

Table 1. Emissions Reductions by Scenario

Scenario	Reduction in 2025 (metric tons)	% of 2025 Transportation Emissions	Progress to 40% Reduction
VMT Reduction	3,746,797	9.1%	48%
Transit Adoption	64,884 - 282,849	0.2% - 0.7%	0.8% - 3.6%
BEV Adoption	368,757	0.9%	4%
Increased Fuel Economy	1,602,896	3.9%	20%

Source: RTI analysis

4. SCENARIO 1

Reducing VMT by 10% by 2025

Our analysis shows that the most impactful near-term way to reduce transportation emissions, is to simply reduce the number of miles travelled every year in North Carolina. The average LDV in North Carolina drives between 13,000 and 14,000 miles every year. At a national level, emissions from LDVs account for roughly 60% of transportation sector emissions. Under this scenario, we considered the emissions benefits of a 10% reduction in miles travelled by LDVs by 2025. The decrease is phased in linearly between 2021 and 2025. As Table 2 shows, we estimated that a 10% reduction in LDV VMT would result in just over 3.7 MMT CO_2 in emission reductions, bringing transportation sector emissions to just over 37 MMT CO_2 in 2025 (see Figure 6). Although 10% is an ambitious target, the magnitude of the benefits under a 10% reduction shows that even a smaller reduction in LDV VMT would yield meaningful reductions in emissions.

POLICIES AND INCENTIVES TO DRIVE VMT REDUCTIONS

Although straightforward, achieving a 10% reduction in VMT by 2025 is ambitious and would not be easy. One important strategy to reduce VMT from LDVs is to increase the use of public transit. We address this in Section 5 of this report because it is a stand-alone scenario (Scenario 2) in our analysis. For the VMT Reduction Scenario, we explored progrwams and policy actions outside of public transit that could drive reductions in VMT, but it is important to recognize that public transit is a critical component to reducing both personal vehicle travel and GHG emissions, especially in conjunction with denser land use planning where parking becomes more constrained.

Strategies that we identified fall into one of two broad categories: land use planning and economic incentives. While some solutions are focused on reducing travel to and from work, most efforts to reduce VMT should be designed to target a variety of trip types. According to the National Household Travel Survey (NHTS), private vehicle travel makes up 78.1% of all VMT in the United States, but work-related travel makes up less than 19% of VMT. Trips for shopping, social gatherings, recreation, and going to school or church make up over 50% of VMT.[6]

Land Use Planning for Fewer VMT

Land use planning aimed at designing communities that are walkable, bikeable, and close to plentiful transit options is often an investment that pays off over the long term given that new planning conventions and zoning regulations play out over many years of real estate development. However, such investments can yield significant benefits and are essential to maximizing VMT reductions.

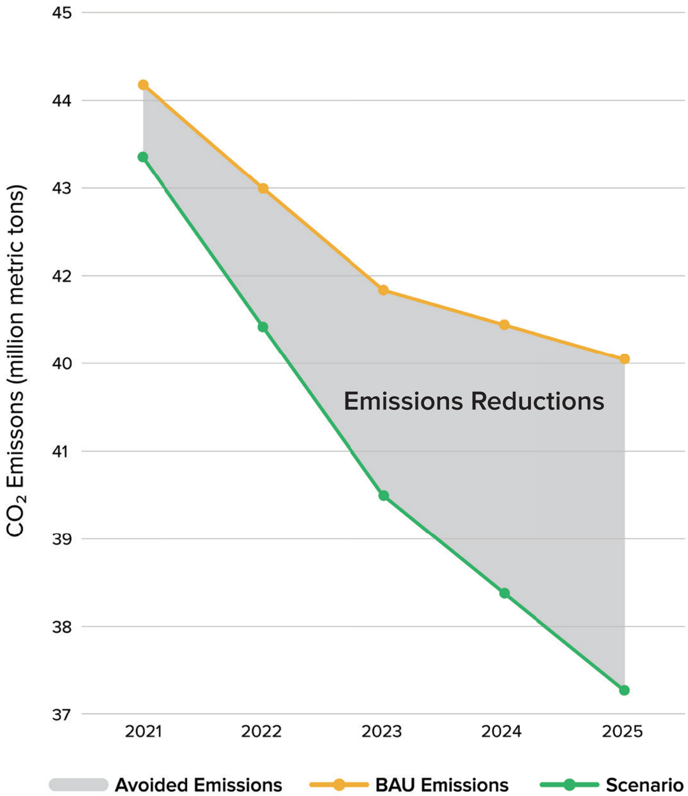
Focus on density. Research clearly shows a link between land use and transportation activity.[7] As density increases, VMT goes down, particularly if land use planning embraces mixed-use development and robust transit development. Supporting municipalities in developing urban plans that emphasize in-fill development, mixed-use real estate, walkability, and transit can enable people to live, work, play, and shop in a much smaller geographic area, reducing or

Table 2. Summary Results, VMT Reduction Scenario, 2021–2025

Measure	2021	2022	2023	2024	2025
BAU LDV VMT (thousands of miles)	115,087,196	116,242,306	117,158,914	117,951,842	118,743,148
VMT Reduction Target (%)	2%	4%	6%	8%	10%
Scenario LDV VMT (thousands of miles)	112,785,452	111,592,614	110,129,379	108,515,695	106,868,833
Avoided CO_2 Emissions (MT)	810,847	1,596,740	2,349,381	3,066,735	3,746,797
Cumulative Avoided CO_2 Emissions (MT)	810,847	2,407,586	4,756,967	7,823,701	11,570,499

Source: RTI analysis

Figure 6. Projected Emissions Reductions, 2021–2025: VMT Reduction Scenario



(NOTE: Scale does not start at zero)
Source: RTI analysis

eliminating the need for a car for some people.

Large, dense cities such as New York City and Boston amply demonstrate the possibilities of high-density land use planning, but a focus on density need not imply clusters of skyscrapers and cramped apartments. In fact, even modest changes in land use patterns can significantly increase density. The Victoria Transport Policy Institute (VTPI), for example, demonstrates that the land required to house 1,000,000 homes can be reduced by 45% simply by shrinking the average lot size of single-family homes and increasing multifamily housing by just 15%.[8]

However, achieving higher density urban spaces will take time; state and local governments need to act in the near term to unlock long-term benefits. To do so will require changes to existing building codes, zoning laws, and street design.

Move away from loop- and bypass-centric highway planning. Loop and bypass highway development is often touted as a congestion management and growth management strategy, but research shows that loops and bypasses can have devastating environmental impacts because they encourage low-density sprawl, further exacerbating our dependence on cars to get around and converting land away from other productive uses or ecosystem services.[9] Instead of trying to move congestion out of and around cities with loops

Call-Out Box 1. Pros and Cons of VMT taxes

VMT taxes have been held up as a solution to flagging revenues from gas taxes, which are the primary source of infrastructure funding in most states (and at the federal level). A VMT tax is already being piloted in some states, including Oregon, Delaware, California, and Colorado. For example, Oregon charges 1.7 cents per mile to residents of the state in a voluntary alternative to the gas tax, but this amount is removed from the total gas tax paid by residents.[10]

Gas taxes have been criticized in recent years because most are not tied to inflation, meaning that revenues from these taxes have been declining in real terms for decades in most states. Additionally, increasingly efficient vehicles that use less gas but drive the same miles have put downward pressure on revenues.

In practice, though, VMT taxes have several problems. First, a flat per-mile tax does not account for weight or fuel economy, disincentivizing consumers from buying lighter and more efficient vehicles. Second, the vehicle owner pays the tax to the state they reside in, regardless of where the miles are driven. Creating a variable VMT tax to account for these factors would increase the administrative burden of administering the tax. In addition, there are privacy concerns related to monitoring miles driven within each state.[11]

In contrast, a gas tax naturally disincentivizes heavy, inefficient vehicles and is geographically more closely tied to where the miles are being driven because it is paid at the pump. It is also very simple to collect and administer. Its main historical weakness—not being tied to inflation—is an easy fix. In fact, in 2015, the state gas tax in North Carolina was restructured to index it to population growth and inflation starting in 2017.[12]

A final criticism of the gas tax is that alternative fuel vehicles, particularly EVs, do not pay gas taxes and therefore do not contribute to state infrastructure funds. In response, 24 states have imposed annual EV fees averaging $128 per year.[13] However, in many cases, the fee exceeds what an average vehicle would pay in gas tax every year. North Carolina's EV fee of $130 is higher than the average.

Rather than impose a separate fee structure for EVs, North Carolina should maintain the gas tax model and charge EV owners based on the fuel economy of their EV in miles per gallon equivalent (MPGe). This approach would harmonize the fee structure with the gas tax model, ensure that EVs are contributing to funding road maintenance and new infrastructure, and maintain an incentive to adopt more efficient vehicles.[14] To counteract the decline in funding as vehicles become more efficient, the gas tax should be inversely indexed to total fuel consumption in the state, meaning that if fuel consumption declines, the gas tax increases.

Call-Out Box 2. Co-benefits of Reducing Gasoline Consumption

Although we are primarily interested in GHG emissions reductions for this report, cutting our consumption of fossil fuels yields many other benefits to our health and to the economy. Every gallon of gasoline we use getting to work releases particulate matter, volatile organic compounds, sulfur oxide, and nitrogen oxide into the atmosphere, leading to air pollution, which has been linked to the following adverse health effects:[20]

- **Premature death in people with heart or lung disease**
- **Nonfatal heart attacks**
- **Irregular heartbeat**
- **Aggravated asthma**
- **Decreased lung function**
- **Increased respiratory symptoms, such as irritation of the airways, coughing, and difficulty breathing**

Reducing fossil fuel consumption by improving fuel efficiency, converting to EVs, using active forms of transportation, taking the bus, or simply driving less will have a large immediate impact on local air quality, making North Carolina a healthier place to live today and into the future. Healthier air translates into real economic benefits through reduced health care costs and a healthier, more productive workforce.

Reducing fuel consumption is also good for consumers' wallets and the state economy. According to the U.S. Energy Information Administration (EIA), the average driver in North Carolina spends over $1,100 per year on fuel.[21] This is a significant cost to North Carolina consumers, and with very little oil and gas industry in state, most of this money leaves our state economy. Reducing VMT by 10% in 2025 would save North Carolina consumers over $922 million (2018 USD) at the pump, which can then be spent on goods and services that have a greater positive impact on our local economy.

such as I-540 in Raleigh, state infrastructure planning should focus on reducing VMT and investing in public transit to decrease congestion in denser areas.

Economic Incentives

Basic economics tells us that if the price for something increases, consumers will demand less of it. This principle applies to travel as well.

Implement localized road use charges (RUCs). RUCs directly incentivize drivers to reduce their VMT by increasing the price of driving. North Carolina should evaluate where it makes sense to implement localized RUCs, such as tolls and congestion pricing, to both disincentivize unnecessary travel and reduce congestion. Transit planning and RUC implementation should be closely tied to provide alternative ways of traveling through toll or congestion zones. Additionally, subsidies for lower-income commuters are important to ensure RUCs do not create another barrier to the mobility of low-income communities. An additional benefit to localized RUCs is that they can be implemented relatively rapidly on existing infrastructure, offering a near-term policy option for driving down VMT.

Another form of RUC is a general tax on VMT, but a flat tax on every mile travelled is not without its complications and creates incentives that run counter to the goal of reducing transportation emissions. See Call-out box 1 for a discussion of the pros and cons of a general tax on VMT.

Increase opportunities for flexible work options. As technology and digital communication advance, telework and telecommuting have emerged as a promising strategy for reducing total VMT for commuters. GoTriangle provides resources and consultations with employers to encourage telework,[15] while some transit agencies offer grants to individuals or employers to incentivize telework. Connecticut's Department of Transportation found that among participating companies there was a 74% increase in teleworkers and a 91% increase in teleworking days per week.[16]

Telework has several co-benefits in addition to reducing VMT. Research and surveys show that telework can increase worker productivity and job satisfaction by giving them the flexibility to balance work and personal life. For employers, teleworking options can reduce turnover and the cost of operating large office facilities.[17]

Telework, however, is not without its downsides; it is not applicable for all types of work, especially work that requires face-to-face interaction, and although there is evidence that it reduces total VMT, it can also contribute to urban sprawl because employees have less of an incentive to live close to their workplace.[18] However, this consequence can be mitigated somewhat by other policies that incentivize denser land use development, including building codes and zoning regulations that incentivize mixed-use development and multifamily housing developments.

Promote carpooling, vanpooling, and micromobility. North Carolina should increase support to municipalities to promote carpooling and vanpooling through grants or other funding mechanisms. Funds could support education and awareness programs and defray the operating costs of running vanpool programs. North Carolina's Department of Transportation (NCDOT) is currently a partial funder of ShareTheRideNC.org, a website aimed at helping commuters match with carpool and vanpool partners.

The state should also support municipalities in welcoming micromobility solutions, including bikeshare and scooter-share programs. Support could include grants to fund necessary infrastructure upgrades (e.g., installing bikeshare docks, dedicated bike lanes) or funds for awareness campaigns. One example of infrastructure that facilitates alternative travel modes is the East Coast Greenway (ECG). In the Triangle Region, the ECG is 70 miles long and connects six cities, five universities, 27 parks, and five major trail systems. A recent report from the East Coast Greenway Alliance estimates that the ECG helps avoid over 1.1 million tons of CO_2 emissions every year and 1.4 million miles of on-road travel.[19]

One example of a statewide program that rewards commuters for making alternative commute choices is Georgia Commute Options (GCO). GCO offers different cash incentives to commuters who try an alternative commute. Its flagship program, *Gimme $5*, will pay commuters $5 a day up to $150 for switching from a single-occupancy vehicle trip to an alternative, including carpooling, vanpooling, transit, telework, walking, and biking.

Education and Awareness

Although many responsibilities for transportation planning and transit are devolved to regional and local authorities, state government can provide leadership across the state by funding education and awareness campaigns to encourage North Carolinians to rethink how they travel. Funding could take the form of state-level campaigns, grant programs that support more localized efforts in municipalities, or research and data collection to improve our understanding of attitudes toward public transit, interest in public transit, and the factors that play into commuters' choice of travel mode.

EQUITY SPOTLIGHT

For many low-income workers, transportation is a fixed cost that they have little control over. Any VMT reduction strategies that increase the cost of driving should also feature subsidies to ensure this additional fixed cost does not fall on those who can least afford it. Additionally, many jobs held by low-income workers are not compatible with teleworking (e.g., service, construction). However, incentivizing teleworking could also be paired with efforts to connect more North Carolinians with jobs that are compatible with telework. Such efforts may include expanding broadband connectivity to low-income and rural communities and providing resources for finding remote work that matches individuals' skills. Planning for density and mixed-use developments should also include robust transit access and affordable housing to ensure that people of all income levels have access.

5. Scenario 2

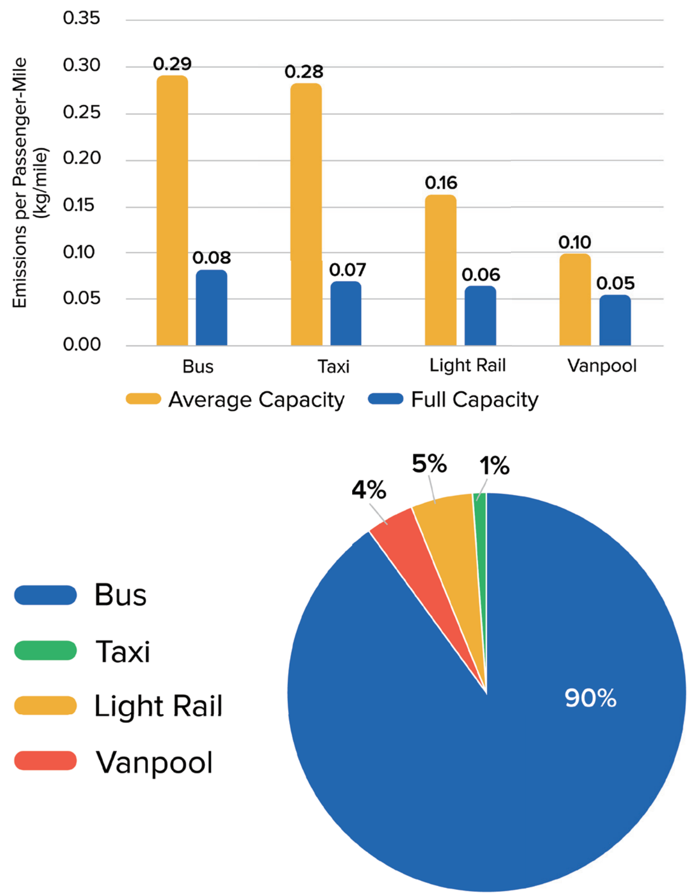
Shift 1% of LDV Traffic to Public Transit by 2025

Although eliminating some VMT altogether is potentially the most impactful way to decrease transportation emissions, we also need to provide more modal options for travel that cannot be eliminated. Shifting LDV travel to less carbon-intense modes is the next best option. Under this scenario, we analyzed the impacts of shifting 1% of LDV traffic to public transit by 2025. Just a 1% shift in LDV VMT would result in nearly 1 billion miles of travel shifting to public transit, which would at least triple public transit passenger-miles.[22]

For this scenario, we drew carbon intensity factors of different transit modes from the Federal Transit Administration (FTA), which provides emissions per passenger-mile by mode at average capacity and full capacity (see Figure 9).[23] Although these estimates are dated and likely higher than the current average carbon intensity of transit modes, they are the most comprehensive available. Additionally, these emissions factors are recommended by the American Public Transportation Association for quantifying GHG emissions from transit.[24] Figure 9 also shows the distribution of passenger-miles by transit mode for North Carolina from the National Transit Database. This distribution was used in the analysis to calculate the GHG emissions benefits of shifting from LDV travel to transit.

Our analysis shows that a shift of 1% of LDV VMT to transit would result in a net emissions reduction of 65,000 to 283,000 metric tons of CO_2, depending on

Figure 9. Emissions Factors and Distribution of Transit Usage by Mode*



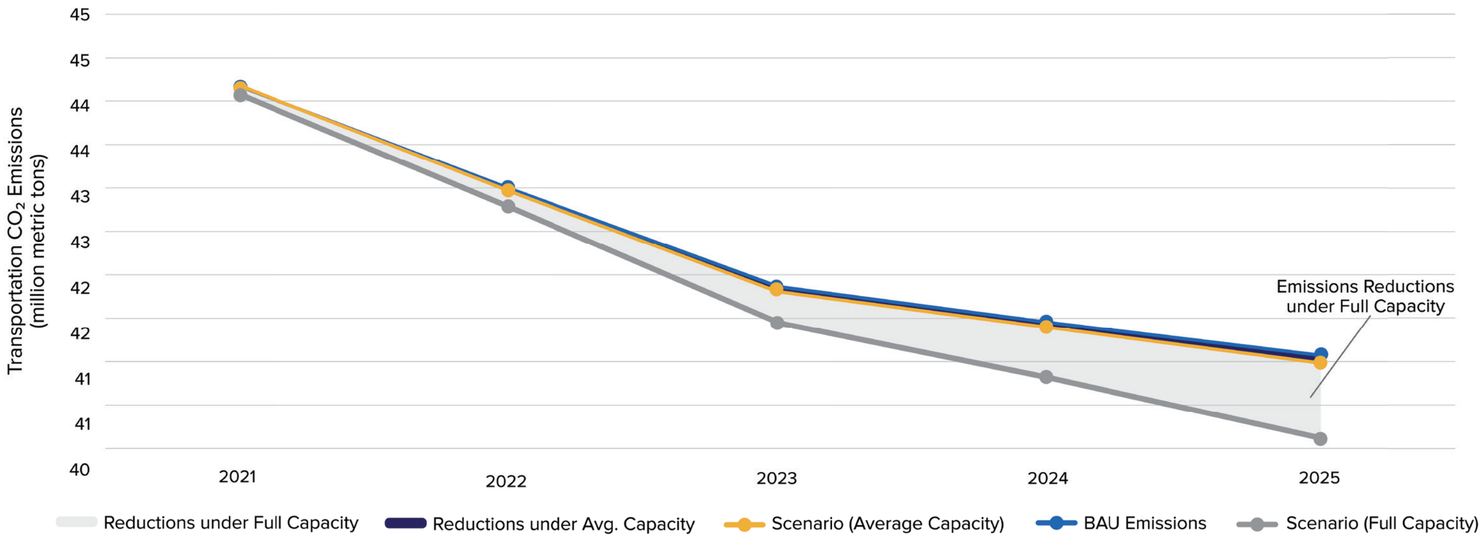
Sources: Emissions factors based on DOT (2010)[21]; distribution of transit usage by mode is from the National Transit Database.[25] *The taxi mode does not have a different "full capacity" emission factor.

Table 3. Summary Results, Transit Adoption Scenario, 2021–2025

Measure	Capacity	2021	2022	2023	2024	2025
% of LDV VMT to Shift to Transit	--	0.2%	0.4%	0.6%	0.8%	1.0%
Miles Shifted to Transit (thousands of miles)	--	230,174	464,969	702,953	943,615	1,187,431
Avoided LDV CO_2 Emissions (metric tons)	--	81,085	159,674	234,938	306,673	374,680
Increased Transit CO_2 Emissions (metric tons)	Average	60,118	121,410	183,500	246,255	309,796
	Full	17,817	35,984	54,389	72,992	91,831
Net Avoided CO_2 Emissions (MT)	**Average**	20,967	38,264	51,438	60,419	64,884
	Full	63,267	123,690	180,549	233,681	282,849
Cumulative Avoided CO_2 Emissions (MT)	**Average**	20,967	38,264	51,438	60,419	64,884
	Full	63,267	186,957	367,507	601,188	884,037

Source: RTI analysis

Figure 10. Projected Emissions Reductions, 2021–2025: Transit Adoption Scenario (NOTE: Scale does not start at zero)



Source: RTI analysis

transit utilization (see Figure 10 and Table 3). From 2021 through 2025, this shift could reduce transportation CO_2 emissions by up to a cumulative 734,000 metric tons.

The results in Table 3 show that at average capacity using FTA emissions factor estimates transit adoption only reduces emissions by roughly 17% relative to LDV travel in 2025. In reality, the benefit is likely larger because buses in particular have become more efficient, on average, since 2010 through adoption of alternative fuels and other mechanisms. Nevertheless, this smaller emissions benefit estimate serves to highlight two points. First, utilization of public transit—how full the buses or trains are—is important. From an environmental perspective, investments in optimizing transit routes are key to maximizing benefits.

Second, alternative fuel transit technology—particularly buses—can significantly increase the environmental benefits of transit as well. Adopting alternative fuels, hybrid electric, or battery electric buses can significantly lower (or even eliminate altogether) emissions from public transit. In 2019, the city of Greensboro became the first transit agency in North Carolina to begin replacing 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.[26] Greensboro expects to save $350,000 over the lifetime of each bus in reduced operating and maintenance costs.

POLICIES AND INCENTIVES TO DRIVE TRANSIT ADOPTION

Because public transit is administered at the municipal level, most policy options apply at the municipal level, but state government can support transit agencies in several ways.

State Actions

Increase funding. More than anything, transit agencies need increased funding. In the 2018–2019 fiscal year in North Carolina, just 3% of appropriations to NCDOT went to public transit and rail.[27] Funding is especially needed to expand service, which not only requires more buses and drivers, but also significant up-front planning and marketing to maximize the probability of launching a successful new route. In providing funding, priority should be given to expanding routes and frequency of buses in low-income communities that rely heavily on public transit to reach jobs and vital services.

Tie funding to predictable, long-term revenue streams. Any funding that is provided must be sufficiently reliable to enable transit agencies to make multiyear investments in growing their transit infrastructure.

Prioritize transit in highway design and operations. On highways that pass through urban areas, buses can easily get bogged down in the traffic that transit is meant to reduce. Because the state has significant input into highway infrastructure planning, North Carolina should prioritize transit access along highway corridors that serve a large commuter population. Some strategies to prioritize transit include widening shoulders to accommodate low-speed bus-on-shoulder operation, incorporating dedicated full-speed bus lanes to facilitate bus rapid transit service, and providing transit signal priority at stoplights.

Support connectivity between service areas. Although NCDOT encourages regionalization of transit services, commuters may still live in one transit service territory and work in another. Consistent with

NCDOT's 2018 *Public Transportation Strategic Plan*, the state should support efforts to connect commuters between service areas.[28] One way to do this is to fund park-and-ride facilities to help workers in rural counties access major employment centers.

Incentivize state employees to use transit. The state can support local transit systems by encouraging state employees to use transit by providing free or reduced-cost passes. In the Triangle region, for example, GoTriangle works with nearly 50 employers to provide the GoPass to employees for free or at low cost.[29]

Fund bus stop improvements. Also consistent with the NCDOT *Public Transportation Strategic Plan*, the state should support safer and more comfortable transit stops, particularly in areas that already serve or have the potential to serve significant traffic. One low-cost way the state can support this and other improvements, particularly in rural counties with less funding, is to provide reference designs and best practices for designing and placing bus stops.

Awareness and education. North Carolina should fund awareness and education efforts to highlight statewide transit corridors and services (e.g., rail service between Raleigh and Charlotte). Additionally, the state should explore providing grants to transit agencies to promote services and provide education to potential transit users.

Municipal Actions

Strategically invest in routes with high demand potential. Availability of service generally requires expanding routes and the number of buses that serve high-demand routes. The best opportunities for growing transit usually lie in connecting low- to moderate-income neighborhoods to more places with better service. Using travel demand modeling, transit agencies can also identify key unserved routes that have the potential for a high level of adoption given the right service offering.

Designate transit-only corridors. Creating transit-only corridors in dense urban settings during peak hours and designated bus lanes throughout the city was one way Seattle has increased its bus ridership by 8% since 2014.[30] Increasing the frequency of buses and the reach of bus systems helped cities such as Las Vegas, Vancouver, Boston, Los Angeles, and Oakland increase ridership by 30% to 84% along targeted transit lines.[31] In addition to transit-only corridors, cities can prioritize transit using Traffic Signal Priority (TSP) technology, which allows buses to control traffic signals. TSP technology can reduce travel time by up to 18%.[32]

First- and last-mile solutions. Public transit promotion extends beyond just buses and rail systems. First- and last-mile solutions can incentivize the use of public transit, especially in rural or suburban settings where the distance to nearby transit can be a barrier to its use. Washington, DC, and Baltimore provide park-and-ride solutions for easier access to transit hubs.[33] Access to greenways and bike paths from transit hubs is another alternative that could promote the use of public transit.[34] In dense urban areas, locating bike-share and scooter-share stations near bus stops can provide "in-fill" mobility for commuters.

Decrease friction. Making transit more effortless through technology can help persuade residents who might have outdated ideas about how difficult it is to hop on the bus. Prepaid fare collection, integrated systems for free or discounted transfers, convenient and reliable user information, and mobile payments are some examples of ways to decrease friction in the interaction with transit services.[35] For multimodal trips, universal access transit pass programs are often a core feature of transportation demand management programs. These technologies can also simplify paying for transit and can make it more affordable for low-income customers through "fare-capping" policies.

EQUITY SPOTLIGHT

New transit infrastructure should prioritize expanding low-income communities' access to transit. Access to affordable transportation is a key factor in lifting people out of poverty, and locating transit routes where they are most needed increases the sustainability of the route. As technology helps to improve the transit experience, we must take steps to ensure that those without access to technology or traditional banking are not excluded from taking advantage of transit. Buses should always accept cash, and transit agencies need to maintain multiple ways for individuals to plan trips.

6. Scenario 3

Accelerate BEV Adoption

Part of EO80 specifically identifies ZEVs as a key part of achieving emissions reductions in North Carolina's transportation sector and sets a goal of increasing the number of registered ZEVs to at least 80,000 by 2025. The ZEV classification includes BEVs and hydrogen fuel cell EVs.[36] A ZEV can be any weight class of vehicle, including medium- and heavy-duty trucks and buses. Since EO80 was issued, NCDOT has refined the goal to focus specifically on achieving 80,000 BEVs on the road by 2025.

In the short term, BEVs reduce emissions of both GHGs and other pollutants in conventional fuels that are harmful to human health. However, the truly transformational potential of electrifying transportation will play out over the long term because it will take the market time to replace older, dirtier cars with electric vehicles. If BEV sales were to grow to 20% of all LDV sales in 2025, this would result in approximately 310,000 BEVs on North Carolina's roads. Out of roughly 8 million LDVs registered in North Carolina, this would represent just 4% of the total on-road LDV stock in the state. This emphasizes the importance of acting early and aggressively to kickstart the market for BEVs and other electric vehicles in North Carolina. Electric vehicles in North Carolina will also continue to become even cleaner as the electric grid becomes cleaner over time.

For the purposes of this analysis, we specifically focused on the emissions benefits of increased adoption of light-duty BEVs, which rely solely on electricity for power. Commonly known BEV models include the Nissan Leaf, all Tesla models, and the Chevrolet Bolt.

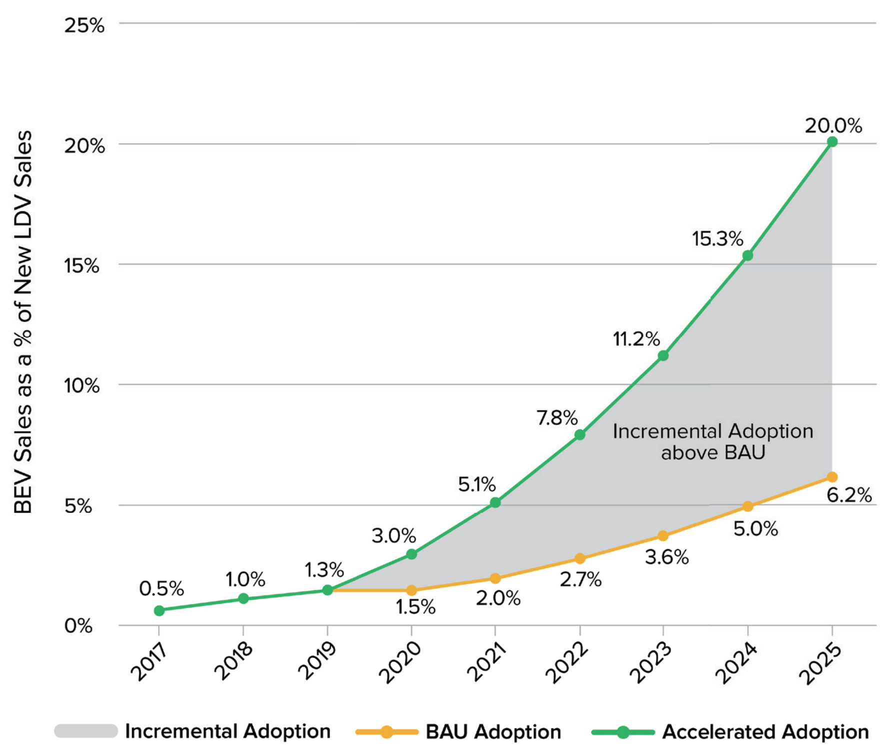
Under this scenario, we modeled the emissions reductions associated with BEVs reaching 20% market share of new LDV sales by 2025. Current estimates from the EIA project that BEV adoption will reach 6.2% of new LDV sales by 2025 for the region, including Virginia and the Carolinas under a BAU Scenario.[37] To reach that milestone, we estimated an adoption curve that diverges from the BAU Scenario starting in 2020 to reach 20% by 2025 (see Figure 11).

The gap between BAU adoption and accelerated adoption represents the incremental adoption that can yield additional emissions reductions beyond the BAU Scenario. Under the BAU Scenario, we estimated that just under 30,000 BEVs will be sold in 2025 in the state, and the total stock of BEVs on the road (which includes vehicles sold before 2025) will be 114,000. With 20% market share of LDV sales in 2025, we estimated BEV sales will total just over 95,000, and the BEV stock on the road will be roughly 310,000.

It is worth noting that the BAU stock value is significantly higher than the goal of 80,000 BEVs outlined in EO80, meaning that the state may achieve its goal without any additional effort to accelerate adoption. Under a scenario that results in 80,000 BEVs on the road in 2025, we would expect to see BEVs capture just over 3% of LDV sales compared with 6.2% under our BAU Scenario. Figure 12 compares the BEV stock trajectories between our BAU Scenario, our 20% market share scenario, and EO80.

Figure 13 and Table 4 present summary results from the analysis. Our analysis finds that accelerating BEV adoption to 20% of LDV sales can yield net emissions reductions of 369,000 metric tons in 2025. This rate of adoption would result in over 190,000 new BEVs on the road over and above BAU between now and 2025.

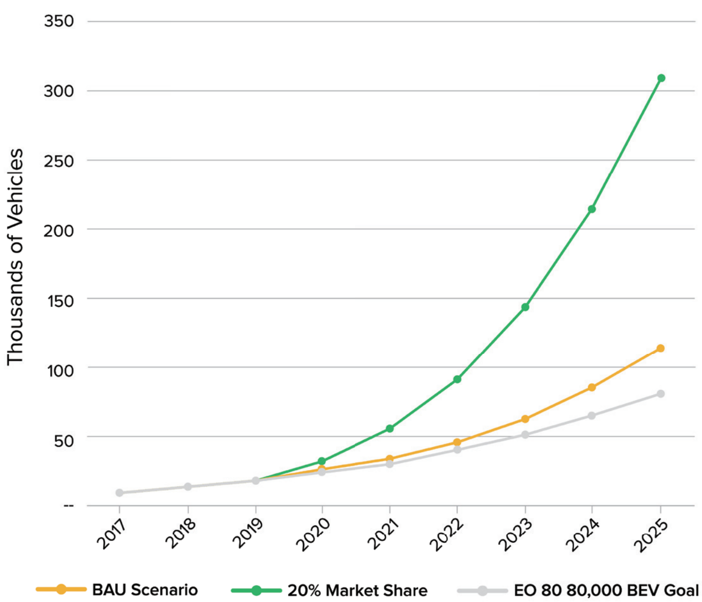
Figure 11. BAU and Accelerated BEV Adoption Curves



Source: RTI analysis

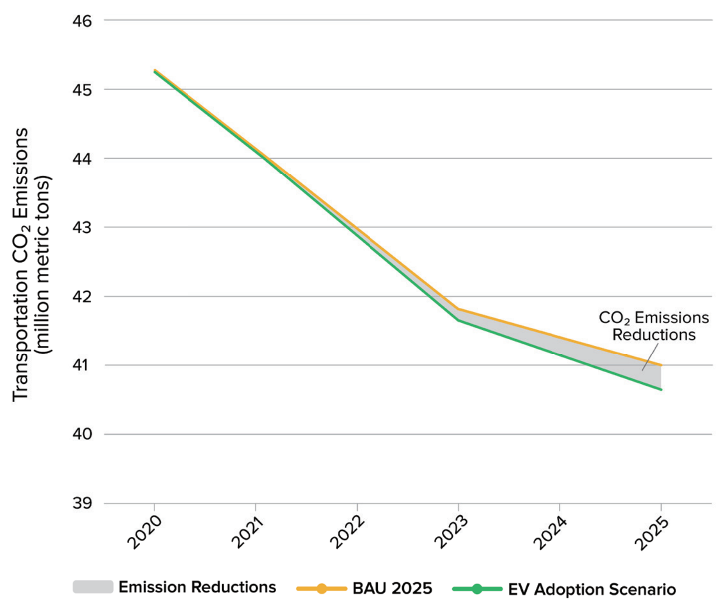
Our results take into account emissions resulting from increased electricity consumption to charge BEVs that are not on the road under the BAU Scenario, which reduces benefits by almost 194,000 metric tons in 2025. The carbon intensity of the electricity grid is a critical factor in reducing transportation emissions through the electrification of vehicles. For this analysis, we estimated the average carbon intensity of the electricity grid in 2025 assuming that North Carolina is on track to achieve a 70% reduction in power sector emissions by 2030 based on the NC Clean Energy Plan recently released by NCDEQ (see the Methodology Appendix for details).[38] Any efforts to reduce emissions from the power sector will yield additional reductions in the transportation sector, increasing the cost-effectiveness of policies in both sectors.

Figure 12. BEV Stock in North Carolina, 2017–2025



Source: RTI analysis

Figure 13. Projected Emissions Reductions, 2021–2025: BEV Adoption Scenario (NOTE: Scale does not start at zero)



Source: RTI analysis

Table 4. Summary Results, BEV Adoption Scenario, 2020–2025

Result	2020	2021	2022	2023	2024	2025
BAU BEV Sales (thousands)	7.08	9.57	12.71	17.33	23.61	29.57
Accelerated Adoption BEV Sales (thousands)	14.45	24.60	37.11	53.46	72.93	95.40
Incremental BEV Sales (thousands)	7.37	15.03	24.40	36.13	49.32	65.83
VMT Converted to eVMT (thousands)	109,221	326,606	672,184	1,173,994	1,845,805	2,727,817
Fossil Fuel Consumption Avoided (gallons)	3,035,016	8,772,421	17,428,988	29,399,310	44,858,473	64,081,696
On-Road Emissions Reductions (MT)	26,647	77,022	153,027	258,126	393,857	562,637
Electricity Consumption for Charging (MWh)	33,961	100,395	204,399	351,455	546,596	798,319
Power Sector Emissions (MT)	12,188	33,701	63,871	101,667	145,431	193,880
Net Emissions Reductions (MT)	**14,459**	**43,321**	**89,156**	**156,459**	**248,426**	**368,757**
Cumulative Net Emissions Reductions (MT)	**14,459**	**57,780**	**146,935**	**303,394**	**551,821**	**920,578**

Source: RTI analysis

TOOLS TO ACCELERATE EV ADOPTION IN NORTH CAROLINA

North Carolina can help accelerate EV adoption in the state through policies and initiatives that signal a long-term commitment to electrification, address up-front and operational costs, and address the charging infrastructure needs in the state.

Signal a Long-Term Commitment to Electrification of Transportation

Electrification of transportation in North Carolina is going to require leadership from the state but also investment from local governments, utilities, private investors, real estate developers, and automakers. Signaling a long-term commitment to electrification can help rally all these stakeholders around a common vision and increase confidence in the future market for EVs in the state.

Set an ambitious EV adoption goal. EO80 sets the goal of 80,000 BEVs on the road by 2025. However, as discussed above, we estimate that under the BAU scenario, North Carolina will have roughly 114,000 BEVs on the road, meaning that the state will meet its 80,000 BEV goal without any additional efforts to accelerate adoption. Setting a more ambitious target signals commitment to accelerating the pace of adoption and reducing transportation emissions, which may help to encourage consumers and the private sector to make similar commitments.

Adopt binding policies. In addition to identifying ambitious targets, North Carolina should adopt binding policies to achieve EV adoption goals. The policy that has shown significant success thus far in the United States is the California ZEV Program, which has been adopted by 11 states, including California. The ZEV program mandates that auto manufacturers sell a certain number of ZEVs each year, reaching roughly 15% of sales in 2025.

One by-product of the ZEV Program is that all major manufacturers are subject to the regulation, ensuring that all EV models available from major automakers would be available in the state. Currently, nine BEV models are available in North Carolina, but up to 15 models are available in other states.

Other binding policies the state should consider include:

- Electrification requirements for government-owned fleets
- New building codes requiring construction of new homes, buildings, parking lots, and parking structures to be designed with EV charging in mind, which will help future-proof new construction

Develop comprehensive plans. North Carolina is already providing leadership at the state level through the development of strategies and studies under the NC ZEV Plan and the NC Motor Fleet ZEV Plan. Further investing in more detailed planning for charging infrastructure investments and progress reporting on implementation of goals laid out under the ZEV plans will demonstrate the state's ongoing commitment to electrification.

Provide dealership incentives. Dealerships are an essential piece of the effort to accelerate adoption of EVs, but research has shown that many dealers, particularly in states without strong ZEV adoption requirements, are resistant to selling EVs, are poorly informed, or do not have an adequate number of EVs on-site to demonstrate and sell.[39] Providing education and incentives for dealerships to embrace EVs can help overcome these significant barriers to consumers learning about, test driving, and purchasing EVs.

Reduce Up-Front Costs

Although prices are dropping, generally EVs cost more up front than a comparable gasoline vehicle but cost less to operate and maintain, making the lifecycle cost of owning an electric vehicle cheaper than a comparable gasoline vehicle. The higher up-front cost may deter lower-income buyers who might otherwise be attracted to the lower operating costs associated with an EV. As part of its October 2019 *North Carolina ZEV Plan*, NCDOT conducted a survey of North Carolina residents about the factors that influence their decision to purchase an EV.[40] The most important factor cited was the availability of a tax credit or cash rebate. This finding is in line with a study conducted by the National Association of State Energy Officials and Cadmus to rank policies for their effectiveness in supporting EV adoption, which found that lowering the up-front cost of an EV is the single most important mechanism for driving new adoption.[41]

Introduce a cash rebate for purchases of new or used EVs at the point of purchase. Currently, 19 states offer tax credits or rebates when purchasing an EV, and evaluations of the impact of these policies have shown that financial incentives significantly increase the level of EV adoption.[42,43] Rebates can also apply to leases, which can significantly reduce a customer's monthly payment.

However, not all credits and rebates are the same. The most effective is a rebate that is filed by the dealer on behalf of the buyer so that the buyer immediately receives the benefit of the incentive. Additionally, the rebate should be accounted for when determining financing terms for the buyer. EV buyers must often prove that they can afford the full purchase price of the vehicle before the rebate is applied. Under a program where the rebate is applied at purchase, this serves only to prevent buyers—particularly lower- or middle-income buyers—from securing the best possible financing terms.

Credits and rebates should also be designed to ensure that buyers of all income levels have access to BEVs by offering higher-value credits or rebates to low-income buyers. Finally, rebates should be available for used cars as well to encourage the development of the secondary market for EVs and expand access to lower-income buyers.

Offer low-interest financing for new and used EVs. Until 2012, North Carolina worked with credit unions in the state to make green vehicle loans available on qualifying vehicles. NCDOT has also made this an action goal in the *2019 ZEV Plan*.[44]

Provide grants or rebates for installing home chargers. While a BEV can be charged using a standard wall outlet, some BEV drivers may choose to install a Level 2 (240V) charger at home to speed up charging time. A charging station is an additional cost to EV owners that may range from $500 to $2,000, depending on the type of equipment and installation costs. In North Carolina, the Cape Hatteras Electric Cooperative and the Randolph Electric Membership Corporation offer rebates to support installing home chargers. Duke Energy, the state's largest utility, does not currently provide any support for home charging, though the company recently submitted a plan to invest in charging infrastructure to the state's public utilities commission. Some of this funding would go to providing home charging. The state could augment these efforts by providing grants, rebates, or tax credits for home charging installation with a particular focus on incentivizing apartment complexes and landlords to install charging infrastructure for EV owners who do not own their own homes.

Reduce Operating Costs

Operating an EV is significantly less expensive than a conventional vehicle. Electricity is cheaper than gas, and EVs require less maintenance.[45] North Carolina can further lower operating costs to incentivize adoption through a number of strategies.

Require the introduction of time-of-use rates for EV charging. Time-of-use rates allow EV owners to access low-cost electricity by charging in the middle of the night. This type of rate is beneficial for the EV owner and for utilities that want to incentivize EV owners to charge during off-peak times when there is less demand.

Provide free or reduced-cost charging. Washington State provides free charging for plug-in electric vehicles (PEVs) at state office locations, and 90% of California PEV owners have access to free public chargers.[46] North Carolina should explore ways to provide free or reduced-cost charging from public infrastructure, focusing on infrastructure that is sited near disadvantage communities or communities where most residents are renters and may not be able to install their own home chargers.

Address Charging Infrastructure Needs

A general rule of thumb is that a region should have roughly one EV charging port for every five EVs. As recently as early 2019, North Carolina's ratio was one port for every seven EVs, meaning that even at the state's current level of adoption, charging infrastructure is inadequate to serve the state's needs. Additionally, a 2019 report from the International Council on Clean Transportation found that to accommodate growth in EV adoption through 2025 in North Carolina's largest metropolitan areas (Charlotte and Raleigh), public charging infrastructure would need to at least double.[47] To meet more aggressive targets, growth in charging infrastructure needs to accelerate even more rapidly than growth in adoption.

North Carolina is already investing significantly in developing new public charging infrastructure using funds from the settlement of the legal dispute between Volkswagen and the U.S. Environmental Protection Agency (EPA),[48] but galvanizing further private investment in charging infrastructure could accelerate building out the infrastructure needed to support EV adoption.

Support development of DC fast charging (DCFC) infrastructure. DCFC infrastructure is particularly expensive, ranging from $10,000 to $40,000 per port for the equipment alone and $4,000 to $51,000 for installation.[49] Additionally, demand charges may make the operating costs of a DCFC station higher than an L1 or L2 charger. At the same time, EV owners place a high value on decreasing the time to charge their vehicle, suggesting that DCFC should be a priority, particularly along heavily trafficked corridors. North Carolina can support DCFC development through tax credits or low-interest financing to developers, ensuring a rate of return to utilities operating DCFC stations, and working with utilities and investors to develop DCFC stations that use on-site energy storage and renewable energy to mitigate high-demand charges.

Encourage utility investments in charging infrastructure. Utilities throughout the country have been granted approval to own and operate charging infrastructure or to provide make-ready infrastructure to third-party charging infrastructure developers. Utilities are uniquely suited to provide charging in locations that the private sector may not find attractive early in the market, such as multi-unit dwellings, low-income communities, and less-traveled corridors.

Ensure a healthy, competitive market for charging infrastructure development. While utilities play a critical role developing charging infrastructure, they also have a distinct market advantage, particularly in a highly regulated state like North Carolina. To ensure a healthy, competitive market for developing charging infrastructure, North Carolina should develop a framework that guides utilities on their charging proposals and provides the North Carolina Utility Commission with guidelines on how to review applications.

Guide infrastructure planning to ensure equitable access to charging. Making charging infrastructure convenient to communities of all income levels and expanding access to charging for renters and residents of multi-unit dwellings are key elements of equitable access to EVs. States such as California, Colorado, and Massachusetts have laws to protect access to electric vehicle supply equipment (EVSE) on residential and commercial property. For example, in California, landlords or lessors must agree to requests for putting EVSE on residential or commercial land.[50] In Massachusetts, owners of public paid EVSE must provide reasonable payment options that don't require extra paid memberships or subscriptions.[51]

Mandate support for charging infrastructure in new construction. North Carolina should set minimum standards for new construction to support charging infrastructure. New parking lots and parking decks should have a minimum number of required EV charging stations per 100 parking spots. New residential construction—both single-family homes and multifamily developments—should also be ready-made to support the installation of L2 chargers.

EQUITY SPOTLIGHT

Ensuring that low-income individuals and communities have access to cleaner EVs requires addressing cost and charging infrastructure. Income-based rebates can ensure that those who need the most assistance in adopting an EV have access to it. Plans for charging infrastructure also need to consider low-income communities where multifamily housing is high and homeownership is low because these housing factors present additional barriers to having ready access to charging at home.

7. Scenario 4

Achieve 54.5 mpg Average New LDV Fuel Economy by 2025

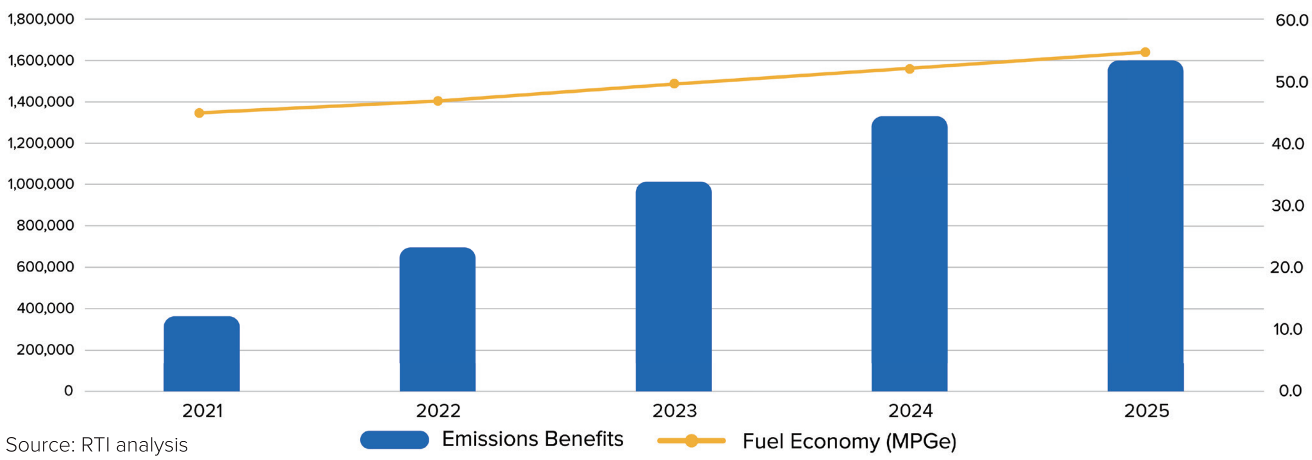
In October 2012, the U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) issued a roadmap of standards for improving the average fleetwide fuel economy to 54.5 mpg by 2025. The updated Corporate Average Fuel Economy (CAFE) standards are broken into two phases. The first phase applies to model year (MY) 2017–2021 vehicles, which mandates that all new vehicles sold average 40.3 to 41.0 mpg. The second phase, applying to MY 2022–2025, has not yet been announced, but the overarching goal was for the average fuel economy of all new light-duty cars and trucks sold to reach 54.5 mpg by 2025. When the new regulation was first announced, the U.S. EPA estimated that the CAFE standards would prevent 6 billion tons of CO_2 emissions from cars sold between 2012 and 2025.

Under this scenario, we estimated the emissions benefits to North Carolina if the 2012 CAFE standards are maintained through 2025. Our assumptions in this scenario are based on fuel economy projections from EIA's Annual Energy Outlook (AEO) 2019, which projects that average fuel economy for new LDVs will reach just 42.4 mpg by 2025 instead of 54.5 mpg. The progression of fuel economy to reach 54.5 under our modeled scenario is drawn from the projected fuel economy targets announced by the U.S. EPA and NHTSA in 2012.[53]

We found that this policy would yield 1.6 MMT CO_2 in emissions benefits in 2025 (see Figure 14 and Table 5). Cumulative reductions between 2021 and 2025 would total almost 5 MMT CO_2 in emissions benefits. Importantly, we do not interpret these results as emissions reductions from our BAU Scenario because the *2019 North Carolina GHG Inventory Report*, which is the basis for our BAU Scenario, assumes that the 2012 CAFE standards are maintained. Instead, these results are illustrative of emissions increases that may result if standards are rolled back, though at the time of this writing, the federal government has not yet finalized new fuel economy standards to replace CAFE.

In 2018, the U.S. EPA announced plans to freeze fuel economy standards in the first phase with no immediate replacement regulation. As of this writing, the Trump Administration has signaled that they may introduce a new standard that mandates a small annual increase in fuel economy going forward, though no official plans have been announced yet.

Figure 14. Projected Emissions Benefits, 2021–2025: Fuel Economy Scenario



Source: RTI analysis

Table 5. Summary Results, Fuel Economy Scenario, 2021–2025

Measure	2021	2022	2023	2024	2025
New LDV Sales (thousands)	488	492	494	497	500
LDV Population, MY21–MY25 (thousands)	488	980	1474	1971	2471
BAU Fuel Economy (MPGe)	35.7	37.3	39.0	40.5	42.4
Target Fuel Economy (MPGe)	44.7	46.8	49.4	52.0	54.5
Avoided CO_2 Emissions (MT)	**362,257**	**694,298**	**1,010,416**	**1,321,307**	**1,602,896**
Cumulative Avoided CO_2 Emissions (MT)	**362,257**	**1,056,555**	**2,066,971**	**3,388,278**	**4,991,175**

Source: RTI analysis

EQUITY SPOTLIGHT

On average, vehicle owners spend around $400 a month maintaining and operating their vehicles, 35% of which is related to fuel consumption.[55] Improving fuel economy is an important component of bringing down the cost of vehicle ownership, particularly for low-income individuals who have less disposable income with which to weather volatile fuel prices. However, it is also important to recognize that low-income individuals that cannot afford a new car may not experience benefits of increased efficiency until new vehicles make their way to the secondary market. Subsidies to support low-income individuals in purchasing high-efficiency new vehicles (e.g. a Cash for Clunkers program targeted at low-income buyers) may help alleviate this barrier.

8. Conclusion

If the transportation sector is going to pull its own weight in reducing emissions of GHGs to 40% below 2005 levels by 2025 in North Carolina, the sector must achieve 7.9 million metric tons of emissions reductions above and beyond the reductions already projected by the *2019 North Carolina GHG Inventory Report*. The scenarios evaluated in this analysis have the potential to provide between 235,000 and 3 million metric tons of CO_2 emission reductions in 2025 from the transportation sector. Several conclusions arise from these findings.

There is no silver bullet. Although this analysis did not examine every option for reducing transportation emissions, the gap between our scenarios and the goal set by EO80 makes clear that achieving the objective of EO80 requires a suite of policies and solutions aimed at delivering transportation emissions reductions. No single policy or mechanism alone can close the gap.

Not only is a suite of solutions essential to meeting North Carolina's emissions reduction goals, but taking a portfolio approach results in greater emissions reductions than individual strategies pursued independently. Shorter term investments to reduce VMT and expand public transit are effectively increasing the efficiency of existing transportation systems. Additionally, electrification of vehicles can reduce emissions and clean up the air North Carolinians breathe.

The time to act is now. Given that many of these policies take time to implement and will have a gradual effect, aggressive action is required to maximize the time available for policies to begin to affect transportation emissions.

Land use planning must evolve as well. The design of our cities and road infrastructure are inseparable from the environmental impact of transportation. Without significant reforms in building codes, zoning laws, urban planning, and highway planning, the effectiveness of any efforts to drive VMT reductions, encourage transit use, or increase BEV adoption will be limited in their effectiveness.

North Carolina has an opportunity to remake transportation with an equity-first mindset. Historically, poor public transportation infrastructure has left low-income individuals with fewer options for accessing jobs, health care, healthy food options, and other essential services. Highway infrastructure planning has also favored wealthier communities at the expense of poor neighborhoods. In the coming years, new technologies and the imperative to lower emissions from transportation will result in dramatic changes in how we get around and how we live, presenting an opportunity to make equitable access to transportation a priority going forward.

Appendix

Methodologies

Scenario 1: VMT Reduction Methodology

RTI International created a model in Microsoft Excel to analyze the reduction in GHG emissions through reducing the annual VMT of passenger vehicles in North Carolina. The model generates projections of net and cumulative avoided GHG emissions for 2021 through 2025.

Key inputs and assumptions of the model include:

- All data are for on-road vehicles only.
- All data are for light-duty cars and light-duty trucks, aggregated into LDVs. Heavy-duty vehicles, which include freight trucks, were excluded from the analysis.
- We assumed a linear reduction in VMT.
- The emissions factor of gasoline was assumed to be 8.78 kg per gallon.
- Future fuel economies are weighted averages of the entire LDV stock provided by EIA's AEO 2019.

National VMT projections were sourced from EIA's AEO 2019 and were scaled to North Carolina levels using North Carolina's 2018 VMT as a percentage of national population projections for each year.

$$VMT_{NC} = VMT_{USA} * (VMT2018_{NC} / VMT2018_{USA})$$

We then applied a linear reduction in VMT starting in 2021 and ending in 2025. Multiplying the VMT reduction target percentage by North Carolina VMT yields target VMT. The target VMT is the basis for our emissions reduction calculations.

$$VMT_{TARGET} = VMT_{NC} * VMT_{\%REDUCTION}$$

For each year, we calculated fuel use for BAU VMT and target VMT.

$$FUEL = VMT_{NC} / MPGge$$

We then calculated CO_2 emissions for the BAU and reduced VMT scenarios.

$$CO_2 = FUEL * EF_{GAS}$$

Net emissions reductions were determined by taking the difference between BAU emissions and emissions under the reduced VMT scenario.

$$\text{Avoided } CO_2 = CO_2\ BAU - CO_{2\ REDUCED}$$

Scenario 2: Transfer Of VMT From LDV to Transit Systems Methodology

RTI created a model in Microsoft Excel to analyze the reduction in GHG emissions through reducing the annual VMT of passenger vehicles in North Carolina by shifting VMT from passenger vehicles to transit systems. The model generates projections of net and cumulative avoided GHG emissions for 2021 through 2025 by comparing reduced emissions from avoided VMT with incurred emissions from increased transit use. Results are provided for a scenario where transit vehicles are operated at average capacity. This is the most likely case. Results were also provided for a scenario where transit vehicles are operated at maximum capacity. This is the most efficient outcome and should be viewed as a best-case scenario.

Key inputs and assumptions of the model include:

- All data pertaining to passenger vehicles are for on-road vehicles only.
- All data pertaining to passenger vehicles are for light-duty cars and light-duty trucks, aggregated into LDVs. Heavy-duty vehicles, which include freight trucks, were excluded from the analysis.
- We assumed a linear shift of VMT from passenger vehicles to transit systems.
- We assumed that the average occupancy of LDVs is 1.0, reflecting that the targeted population includes those who are driving a vehicle with a single occupant rather than carpooling.
- The emissions factor of gasoline is assumed to be 8.78 kg per gallon.
- We assumed that taxi fuel economy is equal to the weighted average fuel economy of light-duty cars provided by EIA's AEO 2019.
- We assumed that the average passenger occupancy of a taxi is 1.0 and the maximum passenger occupancy of a taxi is 4.0.

National VMT projections were sourced from EIA's AEO 2019 and were scaled to North Carolina levels using North Carolina's 2018 VMT as a percentage of national population projections for each year.

$$VMT_{NC} = VMT_{USA} * (VMT2018_{NC} / VMT2018_{USA})$$

We then applied a linear VMT shift from passenger vehicles to transit systems. The assumed average occupancy of LDVs is 1.0. This results in a 1:1 shift from LDV VMT to transit passenger miles. The reduction in LDV VMT and resulting increase in transit passenger miles is calculated by multiplying North Carolina's LDV VMT by a target percentage shift in each year.

$$VMT_{REDUCTION} = TPM_{INCREASE} = VMT_{NC} * VMT_{\%SHIFT}$$

The avoided emissions from reduced LDV VMT were determined by calculating the avoided fuel use, then multiplying the avoided fuel use by the emissions factor of gasoline.

$$FUEL = VMT_{REDUCED} / MPGge$$

$$CO_2 = FUEL * EF_{GAS}$$

The model then calculates incurred emissions from increased transit passenger miles. The increased transit passenger miles were distributed to four transit modes (bus, taxi, light rail, and vanpool) using their 2016 percentage distribution of passenger miles for NC. The incurred emissions for each of the four transit modes were calculated by multiplying their transit passenger miles by a CO_2 emissions per passenger miles constant.

$$CO_2 = TPM * (CO_2/PM)$$

The U.S. DOT provides two emissions per passenger miles values (average capacity and maximum capacity). The above calculation was performed for each of the emissions factors.

Net avoided emissions were calculated by subtracting incurred emissions from avoided emissions for the average capacity and maximum capacity scenarios.

$$\text{Net Avoided } CO_2 = CO_2 \text{ AVOIDED} - CO2_{\text{ INCURRED}}$$

Scenarios 3: BEV Adoption

Under the BEV Adoption Scenario, we estimated the emissions reductions associated with the market for BEVs growing between 2020 and 2025 to capture 20% of LDV sales in 2025. Under Scenario 4, we estimated the emissions reductions if all new vehicle purchases for the state motor fleet are BEVs by 2025. This methodology focuses on the BEV Adoption Scenario and notes where the methods differ for the State Motor Fleet Electrification Scenario.

The following input assumptions informed our analysis:

- Under the BAU Scenario, BEVs would capture 6.2% of LDV sales in 2025.
- The assumed fuel economy for LDVs that were displaced by BEVs in our scenario reflects a weighted average of all non-EV types in the 2019 EIA AEO. Weighting is based on the distribution of sales by vehicle type.
- The assumed fuel economy for BEVs being adopted in our scenario reflects a weighted average of the projected fuel economy for the three BEV technologies in the EIA AEO (100-, 200-, and 300-mile range). Weighting is based on the distribution of sales by vehicle type.
- Adoption of BEVs is assumed to follow an exponential curve as shown in Figure 11.
- Emissions benefits are not estimated for the BEVs that are assumed to be adopted under the BAU Scenario because we assumed this adoption will happen no matter what. Instead, emissions benefits are only estimated for BEVs that are adopted above and beyond the BAU Scenario.
- We assumed a single average VMT per year regardless of vehicle technology.
- We assumed that a small portion of the BEVs sold in each year "drop out" of the stock due to mechanical failure, an accident, or some other cause.

To estimate the number of BEVs sold each year from 2020 through 2025 in North Carolina under both scenarios, we first estimated total LDV sales by scaling national sales projections from EIA AEO 2019 using North Carolina's population as a share of the national population.

$$SALES_{NC} = SALES_{USA} * (POP_{NC} / POP_{USA})$$

Next, we estimated two adoption curves for our BAU Scenario (6.2% market share in 2025) and our accelerated adoption scenario (20% market share). Using these two sales trends, we calculated how many additional BEVs are on the road in 2025 compared with our BAU Scenario. This number includes BEVs sold prior to 2025 and represents the *incremental adoption* associated with our scenario.

Using average VMT per vehicle, we then estimated how many miles of travel are being converted to electric miles because of increased BEV adoption. Using a weighted average fuel economy for non-BEVs, we estimated the reduced tailpipe emissions associated with the increased BEV adoption.

Finally, using miles per gallon equivalent estimates from EIA AEO 2019, we estimated the electricity consumption associated with charging the incremental BEVs on the road. The difference between tailpipe emissions reductions and emissions from additional electricity consumption represents our net emissions benefits from accelerated BEV adoption.

Scenario 4: Improved Fuel Economy Methodology

RTI created a model in Microsoft Excel to analyze the reduction in GHG emissions in North Carolina through fuel economy improvements. The model generates projections of net and cumulative avoided GHG emissions for 2021 through 2025.

Key inputs and assumptions of the model include:

- All data are for on-road vehicles only.
- All data are for light-duty cars and light-duty trucks, aggregated into LDVs. Heavy-duty vehicles, which include freight trucks, were excluded from the analysis.
- Improved fuel economies are based on EPA and NHTSA standards.
- The emissions factor of gasoline is assumed to be 8.78 kg per gallon.
- BAU fuel economies are new vehicle averages provided by EIA's AEO 2019.

The model projects emissions from all new vehicles sold in North Carolina between 2021 and 2025. Baseline emissions were calculated for vehicles using fuel economy projections from EIA. These emissions were compared with emissions resulting from the same population of vehicles with improved fuel economies. The difference in emissions is the net avoided emissions as a result of improved fuel economy.

National sales projections were sourced from EIA's AEO 2019 and were scaled to North Carolina levels using North Carolina population projections as a share of national population projections for each year.

$$SALES_{NC} = SALES_{USA} * (POP_{NC} / POP_{USA})$$

For each year, total VMT attributed to MY 2021–2025 vehicles was determined by multiplying the MY 2021–2025 stock by an average annual VMT by vehicle age constant. MY 2021–2025 stock is the vehicles stock resulting from sales of new vehicles from 2021 through 2025.

$$VMT_{NEW} = STOCK_{NEW} * VMT_{AVG\_ANNUAL}$$

CO_2 emissions for MY 2021–2025 vehicles were calculated using BAU fuel economies and target fuel economies.

Fuel use was calculated using the BAU fuel economies and target fuel economies for each year.

$$FUEL = VMT_{NEW} / MPGge$$

CO_2 emissions were then calculated for the BAU and improved fuel economy scenario.

$$CO_2 = FUEL * EF_{GAS}$$

Net avoided emissions attributed to improved fuel economy were calculated by subtracting CO_2 emissions from vehicles using the target fuel economies from the CO_2 emissions of vehicles using BAU fuel economies.

$$\text{Net Avoided } CO_2 = CO_{2\ BAU} - CO_{2\ TARGET}$$

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