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North Carolina Comprehensive Climate Action Plan

NC DEPARTMENT OF ENVIRONMENTAL QUALITY (NCDEQ)

Prepared as a deliverable through the Climate Pollution Reduction Grants (CPRG) Program, Section 60114(a) of the Inflation Reduction Act

NORTH CAROLINA
Climate Pollution
REDUCTION GRANT

Acknowledgements and Disclaimer

This CCAP identifies a set of greenhouse gas reduction measures that North Carolina may pursue across key economic sectors, with a focus on strategies that are currently supported by existing funding sources or programs. Measures included in this plan reflect known initiatives and investments that are underway or under development. While this plan outlines measurable outcomes and associated benefits, inclusion of a measure does not imply a legal or policy commitment to complete implementation unless funding has been secured for the entire project or program.

This plan was developed in a dynamic policy and funding environment. The analysis reflects the best available information on federal and state programs at the time of drafting, including funding commitments for greenhouse gas (GHG) reduction measures. Recent and potential changes in federal legislation, policies, and agency priorities—along with pending state budget decisions—may affect the availability, scope, or timing of these programs. While the CCAP team has worked to track and incorporate updates throughout the planning process, the projections, measures, and associated benefits in this plan are contingent on the continuation of current or anticipated federal and state policies and funding levels.

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North Carolina's CCAP was developed by staff from NCDEQ, in coordination with the Office of the Governor, the Office of State Budget and Management (OSBM), the North Carolina Department of Transportation (NCDOT), the North Carolina Department of Commerce, and other state agencies and partners. NCDEQ would like to thank the technical experts, state and local government staff, and other stakeholders who contributed their time, insights, and expertise in support of this planning effort.

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Inclusion of stakeholder contributions or referenced programs in this document does not imply endorsement of any specific measure or policy recommendation.

Abbreviations and Acronyms

AFC	Alternative fuel corridors
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
AIM	American Innovation and Manufacturing Act
ARTF	Agrivoltaics Research and Training Facility
BAU	Business-as-usual
BEV	Battery electric vehicles
BIPOC	Black, Indigenous, and People of Color
CCAP	Comprehensive Climate Action Plan
CEJST	Climate and Economic Justice Screening Tool
CFI	Charging and Fueling Infrastructure
CHPP	Coastal Habitat Protection Plan
CMAQ	Congestion Mitigation Air Quality
CO_2e	Carbon dioxide equivalent
COG	Councils of Government
CRPG	Climate Pollution Reduction Grant
CRP	Carbon Reduction Program
DAQ	Division of Air Quality
DCFC	Direct Current Fast Chargers
DOE	U.S. Department of Energy
EECBG	Energy Efficiency Community Block Grants
EnMS	Energy management systems
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EUI	Energy Use Intensity
EV	Electric vehicle
EVSE	Electric Vehicle Supply Equipment
FCS	Forest Land Converted to Settlements
FDP	Forest Development Program (NCFS)
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FLW	Food loss and waste
GESPC	Guaranteed Energy Savings Performance Contract
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory by State
GSP	Gross State Product
GWP	Global warming potential
HAP	Hazardous air pollution
HEAR	Home Electrification and Appliance Rebates
HER	Home Energy Rebates
HFC	Hydrofluorocarbons

HPMS	Highway Performance Monitoring System
HOMES	Homeowners Managing Efficiency Savings
HVAC	Heating, Ventilation and Air Conditioning
HWP	Harvested Wood Products
IAC	Industrial Assessment Center
ICE	Internal combustion engines
IIJA	Infrastructure Investment and Jobs Act
IMD	Integrated Mobility Division
IRA	Inflation Reduction Act
LCS	Land Converted to Settlement
LDV	Light-duty vehicle
LEA	Local education agency
LFG	Landfill gas
LFGTE	Landfill gas to energy
LIDAC	Low-income and disadvantaged community
LiDAR	Light Detection and Ranging
LMOP	Landfill Methane Outreach Project
LULUCF	Land Use Change and Forestry
MHD	Medium/heavy-duty
MOVES	Motor Vehicle Emissions Simulator Model
MSA	Metropolitan Statistical Area
MSW	Municipal solid waste
MT	Metric ton
NASS	National Agricultural Statistics Service
NBS	Nature-based solution
NC	North Carolina
NCCF	NC Coastal Federation
NCDDPA	NC Deep Decarbonization Pathways Analysis
NCDEMLR	NC Department of Energy, Mineral, and Land Resources
NCDEQ	NC Department of Environmental Quality
NCDOT	NC Department of Transportation
NCFS	NC Forest Service
NCORR	NC Office of Recovery and Resiliency
NCUC	NC Utilities Commission
NEVI	National Electric Vehicle Infrastructure
NGO	Non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NWL	Natural and Working Land
ODS	Ozone-Depleting Substance
OSBM	Office of State Budget and Management
PCAP	Priority Climate Action Plan
PFC	Perfluorochemical
PHMSA	Pipeline and Hazardous Materials Safety Administration
RFP	Request for funding proposal

SEDS	State Energy Data System
SEM	Strategic Energy Management
SFLR	Southeastern Forestry and Land Retention
SIT	State Inventory and Projection Tool
SRS	Settlements Remaining Settlement
STI	Strategic Transportation Investment
TDM	Transportation demand management
TNC	The Nature Conservancy
TRAP	Traffic-related air pollution
TREC	Training for Residential Energy Contractor
UNC	University of North Carolina
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VMT	Vehicle miles traveled
VW	Volkswagen
WAP	Weatherization Assistance Program
VOC	Volatile organic compound
ZE	Zero Emission
ZEV	Zero-emission vehicle

Key Definitions

Priority Climate Action Plan (PCAP): a narrative climate planning report that includes a focused list of near-term, high-priority, and implementation-ready measures to reduce GHG pollution and an analysis of GHG emission reductions.

Comprehensive Climate Action Plan (CCAP): a narrative climate planning report that provides an overview of all GHG sources/sinks and sectors following industry standard protocols. The CCAP will establish near-term and long-term GHG emission reduction targets and identify GHG reduction measures to achieve those goals.

Greenhouse Gas (GHG) Inventory: a summary of all GHG emission sources and sinks by sector and the associated emissions quantified using commonly accepted protocols. The CCAP must include a comprehensive inventory of GHG emissions and sinks for the following sectors: industry, electricity generation/use, transportation, commercial and residential buildings, agriculture, natural and working lands, and waste and materials management.

Measure: a measure is a specific, actionable strategy or program designed to reduce greenhouse gas (GHG) emissions in a defined sector.

Metropolitan Statistical Area (MSA): metropolitan statistical areas as defined by the U.S. Census 2020 MSA population. A list of eligible MSAs can be found in Appendix 15.2 of in EPA's CPRG: Formula Grants for Planning, Program Guidance for States, Municipalities, and Air Control Agencies. https ://www.epa.gov/system/files/documents/2023-02/EPA%20CPRG%20Planning%20Grants%20Program%20Guidance%20for%20States-Municipalities-Air%20Agencies%2003-01-2023.pdf

State: all 50 U.S. states and the District of Columbia and Puerto Rico. U.S. federally recognized Tribes and Territories (the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands) must follow CRPG guidance for Tribes and Territories. https://www.epa.gov/system/files/documents/2023-02/EPA%20CPRG%20Planning%20Grants%20Program%20Guidance%20for%20Tribes-Tribal%20Consortia-Territories%2003-01-2023.pdf

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Executive Summary

North Carolina has made steady progress in reducing greenhouse gas (GHG) emissions since 2005, particularly through cleaner electricity generation, early adoption of energy efficiency programs, and leadership in zero-emission vehicle policies. These steps have expanded resiliency, supported economic and workforce development, reduced energy costs, and lowered emissions across the state.

The Comprehensive Climate Action Plan (CCAP), developed by the NC Department of Environmental Quality (NCDEQ) under the Climate Pollution Reduction Grants (CPRG) Program, builds on this progress. With full implementation of the measures included here, the state is on track to meet its goal of reducing GHG emissions by 50 percent below 2005 levels by 2030. This outcome is driven by sector-specific strategies such as increasing options for renewable electricity, improving energy efficiency in buildings, expanding the use of electric vehicles, and expanding land-based carbon sequestration.

Reaching net-zero by 2050, however, will require additional steps beyond current projects and funding.

The NC pathway to success includes:

- Strengthening resiliency through the expansion of microgrids and modernizing grid infrastructure to protect communities from outages and build long-term reliability.
- Accelerating transportation transformation through greater efficiency improvements in freight and transit while increasing the deployment of zero-emission vehicles.
- Increasing upgrades of more efficient heating and cooling systems and deepening building decarbonization by electrifying those systems.
- Reducing waste-sector emissions through food waste diversion, and broader methane control.
- Preserving and expanding solar generation, while advancing offshore wind, long-duration storage, and other zero-carbon technologies.
- Enhancing natural and working lands with expanded restoration, reforestation, and climate-smart practices.
- Advancing industrial solutions by focusing on efficiency and decarbonization measures that align with profitability, while expanding workforce training and technical capacity to support deployment of new technologies.

The CCAP provides a clear near-term roadmap to 2030, while recognizing that long-term success will depend on increasing investments that continue to expand resiliency, support economic and workforce development, continue to reduce energy costs, and lower emissions across the state.

Key Objectives

1. **Strengthen Resiliency and Reduce Climate Pollution:** Support resiliency by modernizing energy infrastructure and investing in more reliable energy systems. Lower household and business energy costs through efficiency upgrades such as weatherization, appliance replacements, and building improvements.

2. **Support Economic Development and Workforce Readiness:** Ensure that communities and industries benefit from the transition by creating opportunities for local jobs, technical training, and workforce development tied to clean energy and decarbonization.
3. **Deliver Cleaner Air and Healthier Communities:** Reduce harmful co-pollutants (e.g., NOx, SO_2, and PM2.5) in residential, work, and recreational areas, improving quality of life while supporting long-term climate and health goals.

Approach

The CCAP builds on the Priority Climate Action Plan (PCAP) by updating and expanding greenhouse gas (GHG) reduction strategies using new data, modeling, stakeholder input, and implementation considerations. While the PCAP set the foundation, the CCAP identifies strategies that are implementable, feasible, and measurable.

The plan addresses six core sectors: electricity generation, industry, transportation, buildings, waste management, and natural and working lands. It also meets the economy wide requirement of the CPRG Program by ensuring that cross-cutting strategies such as workforce development, community engagement, and infrastructure investments are integrated across all sectors to maximize impact.

This approach provides a clear path toward achieving the state's 2030 emission reduction target while revealing options for deeper reductions needed to reach net-zero by 2050.

GHG Inventory, Projections and Targets

North Carolina's GHG inventory and business-as-usual (BAU) projections form the analytical foundation for the CCAP for key sectors (e.g., transportation, electricity) and sinks (e.g., forests). These analyses establish a statewide baseline for past and future emissions and allow the state to evaluate the potential impact of future GHG reduction measures.

North Carolina has formal climate goals that collectively define the state's near- and long-term GHG reduction targets, which strongly align with those in the CPRG Program. These goals were established through executive orders, legislation, and sector-specific planning efforts since 2018.

- **Baseline**: The most recent GHG inventory covers emissions from 1990 to 2020, projecting future emissions through 2050 under a business-as-usual (BAU) scenario.
- **GHG Targets**: Reduce economy-wide GHG emissions to 50% below 2005 levels by 2030 and achieve net-zero emissions by 2050.

Key Measures and Implementation

The CCAP includes 14 measures across the six core sectors.

Table ES-1. List of Sectors and Measures

Sector	Measure	Description
Transportation	Measure 1	Increase the number of medium- and heavy-duty (MHD) zero emission and electric vehicles through programs to replace diesel emission vehicles.
	Measure 2	Identify, install, and maintain a public electric vehicle charging network to support increased EV adoption statewide.
	Measure 3	Implement programs to increase efficiency and reduce GHG emissions at deep water and inland ports.
	Measure 4	Support regional strategies to reduce vehicle miles traveled (VMT). (Unfunded)
Electricity	Measure 5	Increase the amount of electricity generated by renewable resources in North Carolina.
	Measure 6	Implement measures to increase energy resiliency in North Carolina communities: Microgrids for North Carolina Resilience.
Commercial & Residential Buildings	Measure 7	Reduce per square foot energy usage in residential buildings in North Carolina.
	Measure 8	Decarbonize buildings in North Carolina through replacement of fossil fuel combustion sources and other greenhouse gas emissions.
Industry	Measure 9	Industrial Decarbonization Planning and Opportunity Analysis. (Unfunded)
Waste	Measure 10	Reduce food waste entering the waste management system to reduce the methane emissions from food waste landfilling, direct food to communities in need, and create organic resources through composting or digestion.
	Measure 11	Decarbonize waste collection to reduce GHG emissions during the collection and transport of wastes through electrification of fleets or through engine conversion from diesel to electric motors.
	Measure 12	Reduce landfill gas emissions through improved landfill operations to collect gas more efficiently and earlier in a landfill life.
Natural Working Lands	Measure 13	Coastal Habitat Enhancement and Peatlands Restoration
	Measure 14	Protect, use, and develop agricultural and forest land.

Benefits Analysis

- **Co-pollutant Reductions**: Significant reductions in pollutants like NO_X, SO_2, and $PM_{2.5}$, will improve air quality and public health.
- **Economic and Workforce Benefits**: Job creation in clean energy sectors, cost savings from energy efficiency, and support for rural and low-income communities can boost the local economy.
- **Resilience**: Enhanced resilience to extreme weather events through infrastructure improvements and natural habitat restoration will improve energy affordability and reliability.

Community Engagement

The CCAP development process included engaging with a variety of stakeholders, including virtual and in-person sessions, surveys, and interviews. This process ensured that the plan reflects community priorities and addresses local climate risks and opportunities.

Workforce Planning

The plan identifies key workforce needs and opportunities in clean energy sectors, emphasizing the importance of training and job creation to support the transition to a low-carbon economy. The analysis provides valuable insights into the current state of North Carolina's climate-related workforce and highlights opportunities for possible future growth across key sectors.

Moving Forward

In 2027, NCDEQ will provide a CPRG Status Report detailing the implementation status of quantified GHG reduction measures from the CCAP, updated analyses or projections supporting CCAP implementation, and future steps and resource needs for continued implementation. This report will also include any updates to the GHG inventory and BAU projections that have occurred due to regulatory changes at the federal and state levels.

North Carolina's CCAP has been developed during a period of rapid change in federal and state policy and funding landscapes. The analysis and measures presented reflect the most current information available on GHG reduction programs, incentives, and regulatory frameworks at the time of drafting. However, evolving federal legislation, shifting agency priorities, and pending state budget decisions create inherent uncertainty about the long-term availability and scope of funding streams that underpin several measures in this plan.

Importantly, North Carolina did not receive a direct Climate Pollution Reduction Grant Implementation Grant. The state is participating in a multi-state coalition that secured an implementation award focused on supporting conservation and restoration of natural lands, and North Carolina will benefit from that regional effort. However, for the majority of measures outlined in this plan, primary reliance remains on existing or anticipated funding from other state and federal programs, many of which are subject to change or in danger of being eliminated altogether. Without direct implementation funding from the CPRG program, the overall pace of action in North Carolina will necessarily be slower, and progress toward near- and long-term climate goals may take longer to achieve. While the CCAP outlines a clear

and actionable path forward, its successful execution will depend on sustained policy support, timely funding allocations, and continued collaboration among state, local, and federal partners.

1 Introduction

Climate change continues to present serious risks to North Carolina's health, safety, economic stability, and natural systems. In response to the growing threat of rising greenhouse gas (GHG) emissions, Governor Roy Cooper issued Executive Order No. 80 (2018) and Executive Order No. 246 (2022), establishing a clear policy directive.[1,2] These orders recognize that addressing climate change not only protects communities and ecosystems but also creates opportunities for clean energy investment and economic development, particularly in communities that are rural, low-income, and have a high energy burden.

The Inflation Reduction Act of 2022 established the Climate Pollution Reduction Grant (CPRG) Program, administered by the U.S. Environmental Protection Agency (EPA).[3] The CPRG program provides funding to states, metropolitan areas, territories, and tribes to develop and implement strategies that reduce GHG emissions and co-pollutants.[4] EPA established three key objectives for the CPRG program:

1. **Reduce Climate Pollution**: Implement more efficient transportation options by adopting lower emitting vehicles like electric vehicles. Lower energy costs by upgrading to energy efficient appliances, weatherizing buildings, and pursuing more resilient energy sources.
2. **Empower Community-Driven Solutions**: Engage local communities in climate action.
3. **Deliver Cleaner Air**: Reduce harmful co-pollution (e.g., NOx, SO2, and PM2.5) in residential, work, and recreational areas.

These objectives and the overall CPRG Program support North Carolina's climate goals. This document describes how North Carolina plans to use the CPRG Program to plan its near term climate actions and the estimated contributions of those actions towards its climate goals.

1.1 CPRG Overview

The Climate Pollution Reduction Grant (CPRG) Program, authorized under Section 60114 of the IRA, aims to provide $5 billion in total funding to support climate planning and implementation across states, municipalities, tribes, and territories. The national program is structured in two phases.[5] Phase 1 allocated $250 million in noncompetitive planning grants to support the development of Priority Climate Action Plans (PCAPs), Comprehensive Climate Action Plans

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[1] *Cooper, R. (October 29, 2018). "Executive Order No. 80: North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy. https://www.deq.nc.gov/environmental-assistance-and-customer-service/climate-change/eo80-nc-s-commitment-address-climate-change-transition/download.*

[2] *Cooper, R. (2022, Jan. 7). "Executive Order 246: North Carolina's Transformation to a Clean, Equitable Economy." https://governor.nc.gov/executive-order-no-246/open.*

[3] *Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818 (2022). https://www.congress.gov/bill/117th-congress/house-bill/5376/text.*

[4] *U.S. Environmental Protection Agency. (2025). Climate Pollution Reduction Grants. https://www.epa.gov/inflation-reduction-act/climate-pollution-reduction-grants.*

[5] *Inflation Reduction Act of 2022, Pub. L. No. 117-169, § 60114, 136 Stat. 1818, 2076 (2022). Text - H.R.5376 - 117th Congress (2021-2022): Inflation Reduction Act of 2022 | Congress.gov | Library of Congress.*

(CCAPs), and Status Reports. These plans are intended to identify actionable strategies to reduce GHG emissions across six economic sectors: electricity generation, industry, transportation, buildings, waste management, and natural and working lands. Information about the North Carolina CPRG Program and the PCAP can be found on the NCDEQ CPRG webpage here: https://www.deq.nc.gov/energy-climate/state-energy-office/inflation-reduction-act/climate-pollution-reduction-grant.

North Carolina received a Phase 1 CPRG Planning Grant in 2023 to support the development of its PCAP and CCAP.[6] In March 2024, the North Carolina Department of Environmental Quality (NCDEQ) developed and submitted a PCAP.[7] The PCAP identified 15 key measures across the six economic sectors. These measures were selected through consultation with state agencies and stakeholders and reflected feasible and implementable, near-term strategies to reduce emissions while delivering co-benefits such as improved public health, cost savings, and increased resilience.

Phase 2 of the CPRG Program made $4.6 billion in competitive implementation grants available to states to fund the execution of measures identified in PCAPs. In April 2024, NCDEQ applied for $199 million in CPRG implementation funding to advance measures outlined in the PCAP.[8] NCDEQ was not directly awarded funds. In the summer of 2024, however, EPA awarded $421 million in implementation funding to a multi-state coalition led by NCDEQ's sister agency, the North Carolina Department of Natural and Cultural Resources (NCDNCR) to support conservation and restoration of natural lands in North Carolina, South Carolina, Virginia, and Maryland.[9] This funding supports the Natural Working Lands measures 13 and 14.

1.2 CCAP Purpose and Scope

The purpose of North Carolina's CCAP is to present an updated and expanded set of strategies, technologies, and implementation pathways to help the state achieve its near- and long-term GHG emissions targets. The CCAP covers six core sectors identified in EPA's CPRG planning guidance: electricity generation, industry, transportation, buildings, waste management, and natural and working lands, which includes agriculture. The plan serves as a forward-looking framework to help guide coordination, investment, and policy development across agencies and partners.

The CCAP is the second major deliverable under the CPRG Planning Grant and is due to EPA by December 1, 2025. The CCAP builds on the foundation of the PCAP by updating and expanding North Carolina's GHG reduction strategies using new data, modeling, stakeholder input, and implementation considerations. It incorporates the most recent GHG inventory (Section 2),

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[6] *North Carolina Department of Environmental Quality, (2023) Climate Pollution Reduction Grant. NC DEQ. https://www.deq.nc.gov/energy-climate/state-energy-office/inflation-reduction-act/climate-pollution-reduction-grant.*

[7] *North Carolina Department of Environmental Quality. (2024). North Carolina Priority Climate Action Plan. NC DEQ. https://www.deq.nc.gov/north-carolina-priority-climate-action-plan-climate-pollution-reduction-grant/open.*

[8] *North Carolina Department of Environmental Quality. (2024). NC CPRG statewide implementation grant snapshot. NC DEQ. https://www.centralpinesnc.gov/sites/default/files/uploads/cprg-implementation-grant-overview-april-2024.pdf.*

[9] *Office of Governor Roy Cooper. (2024, July 22). Governor Cooper and NCDNCR announce historic $421 million award to bipartisan multi-state coalition supporting conservation and restoration. NC.gov. https://governor.nc.gov/news/press-releases/2024/07/22/governor-cooper-and-ncdncr-announce-historic-421-million-award-bipartisan-multi-state-coalition.*

evaluates statewide emissions sources and sinks, and includes cross-cutting analysis of workforce development, and resilience. Although NCDEQ did not receive federal implementation funding, the CCAP is a vital planning tool to help the state identify feasible, implementable, and measurable pathways to reach net-zero GHG emissions by 2050.

This CCAP expands upon the PCAP by updating and adding information on relevant plans, policies, and projects developed since the PCAP submission. In doing so, the CCAP reflects the most current understanding of program readiness, implementation feasibility, and stakeholder priorities. Measures included in the CCAP are designed to be replicable, resilient, and actionable across state, regional, and local contexts. Some strategies will require further funding and development, while others are already underway or supported by existing resources. Together, these measures form a planning-based foundation for achieving North Carolina's climate targets.

1.3 Approach to Developing the CCAP

North Carolina's CCAP serves distinct purposes shaped by differing expectations for federal support from the PCAP. The CCAP focuses on quantifying the GHG reductions associated with programs and projects that already have committed funding and are actively being implemented across the state. For example, the CCAP highlights emissions reductions from the State Energy Office's Weatherization Assistance Program (WAP) and Energy Saver NC, both of which are federally funded and underway.[10,11] Similarly, the CCAP also captures measurable impacts from NCDEQ's use of VW Settlement funds to expand EV infrastructure and replace diesel vehicles with electric alternatives.[12] These programs and projects are measurable, feasible, and demonstrably implementable.

In short, while the PCAP was aspirational and designed to position North Carolina for competitive federal funding, the CCAP is grounded in currently funded and operational efforts, presenting a realistic snapshot of near-term GHG reductions already underway.

The CCAP is also designed to support and complement the growing climate planning work occurring at the local level. Many cities and counties in North Carolina, such as Asheville, Boone, Greensboro, and Wilmington, have developed their own Climate Action Plans in recent years.[13,14,15,16] These plans typically include GHG reduction targets through 2030 or beyond,

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[10] *North Carolina Department of Environmental Quality. (n.d.) Weatherization Assistance Program. NC DEQ. https://www.deq.nc.gov/energy-climate/state-energy-office/weatherization-assistance-program.*

[11] *North Carolina Department of Environmental Quality. (n.d.) Energy Saver North Carolina. NC DEQ. https://www.deq.nc.gov/energy-climate/state-energy-office/energy-saver-north-carolina.*

[12] *North Carolina Department of Environmental Quality. (n.d.) Volkswagen Settlement. NC DEQ. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement.*

[13] *City of Asheville. (2023, March 28). Municipal Climate Action Plan. AshevilleNC.gov. https://www.ashevillenc.gov/department/sustainability/climate-initiatives/municipal-climate-action-plan/.*

[14] *Town of Boone. (2024, March 14). Boone Community Climate Action Plan. https://www.townofboone.net/DocumentCenter/View/3095/Boone-Community-Climate-Action-Plan.*

[15] *City of Greensboro. (2022, December 20). Strategic Energy Plan. https://www.greensboro-nc.gov/departments/office-of-sustainability-and-resilience/strategic-energy-plan.*

[16] *City of Wilmington. (2016, May 1). Create Wilmington Comprehensive Plan. https://www.wilmingtonnc.gov/Development-Business/Plans-and-Initiatives/Comprehensive-Plan.*

addressing sectors such as electricity, buildings, transportation, natural landscapes, and waste management. They also emphasize resilience to extreme weather events and electric grid disruptions. New Hanover County is among the jurisdictions currently developing a plan, with publication expected in late 2025.[17] Emission reductions from these local plans are not directly counted in the CCAP to avoid potential double-counting. These local efforts, however, represent significant and complementary action that supports statewide process toward climate goals.

In this context, the CCAP can serve as a model planning document for local jurisdictions, including municipalities and metropolitan statistical areas that did not receive CPRG funding. By focusing on strategies that are tied to existing funding and already underway, the CCAP offers a grounded and replicable approach to climate planning. Local governments can refer to the CCAP for sector-specific methodologies, examples of cost-effective programs and their respective funding sources. It provides a template for tracking GHG impacts in a consistent, transparent, and implementation-focused manner. In this way, the CCAP functions not only as a statewide emission reductions plan, but also as a practical tool for local climate action planning across North Carolina.

North Carolina's CCAP builds upon the foundation established during development of the PCAP, while expanding and refining measures in alignment with EPA CPRG guidance. The process followed six key steps, shown in Figure 1.

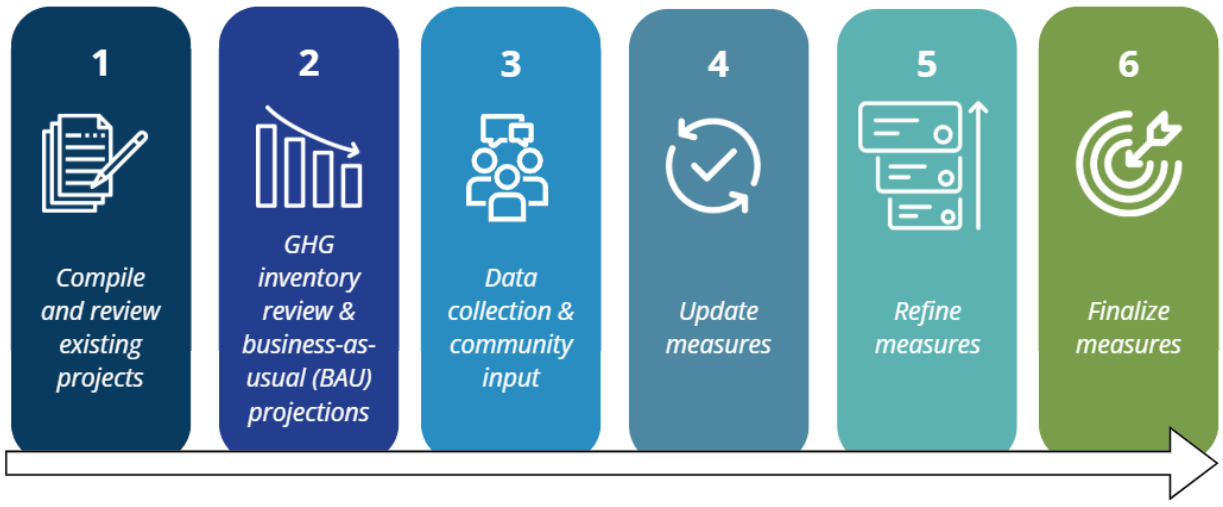


Figure 1. CCAP Measure Development Steps

These steps are further described below:

[17] *New Hanover County. (2023, August 29). Plan NHC: Destination 2050. https://hhs.nhcgov.com/2641/Comprehensive-Plan-Update.*

1. **Compile and Review Existing Plans and Projects**
   The planning team began by reviewing relevant state, regional, and local plans, policies, and funded projects published since the PCAP. This included legislative updates, executive orders, and ongoing initiatives in energy, transportation, and land use. A gap analysis helped identify where additional action or coordination was needed to achieve North Carolina's climate goals.
2. **GHG Inventory Review and Business-As-Usual (BAU) Projections**
   The CCAP reaffirmed use of the state's existing EPA-compliant GHG inventory as the basis for all emissions analysis.[18] Using this inventory, a BAU scenario was developed to estimate future emissions in the absence of additional interventions. The state also confirmed its GHG reduction targets, consistent with the PCAP, EPA guidance, and North Carolina's executive and legislative directives.
3. **Data Collection and Community Input**
   The state collected updated emissions, programmatic, and demographic data from a variety of sources, and conducted outreach to community members, regional partners, and stakeholders. Input from this process informed both the structure and feasibility of proposed measures and helped identify implementation barriers, funding constraints, and equity considerations.
4. **Update the Measures**
   Building on the PCAP's initial list of GHG reduction measures, the team conducted a full review to assess alignment with current conditions, programs, and funding availability. Measures were added, updated, or removed based on technical input, stakeholder feedback, and the outcomes of the gap and feasibility analyses.
5. **Refine the Measures**
   Each draft measure was further refined to ensure it met EPA expectations for planning-level work: clearly defined, measurable, and feasible within existing programs and budgets. This step focused on quantifying potential GHG impacts and identifying lead implementers, co-benefits, and constraints.
6. **Finalize the Measures**
   The final CCAP includes 14 measures across key sectors, selected for their potential to achieve meaningful emissions reductions under current funding realities. Each measure was documented with supporting analysis, implementation assumptions, and alignment with state and federal climate goals.

1.4 Natural and Working Lands (NWL) Sector Approach

The NWL section of the CCAP highlights key projects from the Atlantic Conservation Coalition (ACC) work planned in North Carolina and presents important ways in which GHG emissions are offset in the state.[19] The ACC is a regional partnership among North Carolina, South Carolina, Virginia, and Maryland that leverages nature-based climate solutions to reduce GHG

[18] *North Carolina Department of Environmental Quality. (2024, January 31). Greenhouse Gas Inventory. NC DEQ. https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory.*
[19] *Office of Governor Roy Cooper. (2024). Atlantic Conservation Coalition Climate Pollution Reduction Grant Overview. NC.gov. https://governor.nc.gov/atlantic-conservation-coalition-overview/open.*

emissions, build climate resilience, and deliver co-benefits for communities and ecosystems.[20] Formed in 2023, the ACC was coordinated and co-led by The Nature Conservancy (TNC) alongside key state agencies: the North Carolina Department of Natural and Cultural Resources (NCDNCR), South Carolina Office of Resilience, Virginia Department of Environmental Quality, and Maryland Department of the Environment. The coalition was established to pursue shared goals across state lines, with TNC facilitating the EPA CPRG application and managing the framework for coordinated implementation. In 2024, the ACC was awarded a $421 million EPA CPRG implementation grant to support large-scale ecosystem restoration projects across the four states.

In North Carolina, ACC funding is being used to restore more than 600 acres of coastal wetlands, reforest over 55,000 acres, plant 1,200 urban trees, and permanently protect 3,300 acres within the state park system. These projects are designed to generate measurable emissions reductions while also enhancing community resilience, improving water quality, and providing recreational and economic benefits. The ACC's efforts in North Carolina align with existing commitments under Executive Order 305 and the state's Natural and Working Lands Action Plan.[21,22] To ensure transparency and accountability, the ACC has partnered with Duke University's Nicholas Institute to publicly track project implementation and benefits through an online dashboard. North Carolina's role in the ACC reflects a strong alignment between state priorities and the EPA's goals of climate-smart conservation, equity, and durable emissions reductions.

1.5 Coordination and Contributing Organizations

CCAP development was led by NCDEQ with participation from multiple divisions and agencies. Coordination included:

- Internal sector leads from NCDEQ divisions (Air Quality, Coastal Management, Water Resources, Energy, Waste Management, Environmental Assistance and Customer Service, and Environmental Education)
- North Carolina Department of Transportation
- North Carolina Department of Commerce (for workforce and economic impacts)
- Technical assistance and modeling support from ICF
- Regional coordination with the two CPRG-funded MSAs—Centralina and Central Pines—to ensure complementary strategies. NCDEQ and the Metropolitan Statistical Areas (MSAs) engaged in coordination to reduce duplication and clarify jurisdictional roles, particularly for strategies with overlapping state-regional relevance.

[20] *Nicholas Institute for Energy, Environment, and Sustainability. (n.d.). Atlantic Conservation Coalition dashboard. Duke University. https://experience.arcgis.com/experience/5173013478eb4cf699157a696095478f/.*

[21] *Office of Governor Roy Cooper. (2024, February 12) Executive Order No. 305: Natural Working Lands. NC.gov. https://governor.nc.gov/executive-order-no-305.*

[22] *North Carolina Department of Environmental Quality. (n.d.). Natural and Working Lands Action Plan: Building North Carolina's green infrastructure. NC DEQ. https://www.deq.nc.gov/energy-climate/climate-change/adaptation-and-resiliency/natural-working-lands.*

1.6 Resource Considerations

The CCAP reflects both North Carolina's climate goals and the practical constraints of available resources. The state prioritized measures that are the most feasible, measurable, and implementable opportunities available during the CCAP planning period, based on current funding levels, program readiness, and stakeholder input. While additional opportunities exist, particularly in innovation, equity, and cross-sector coordination, these will require future investment or support through future funding opportunities.

2 Greenhouse Gas (GHG) Inventory and Business-as-usual (BAU) Projections

North Carolina's GHG inventory and business-as-usual (BAU) projections form the analytical foundation for the CCAP for key sources (e.g., transportation, electricity) and sinks (e.g., forests). These analyses establish a statewide baseline for past and future emissions and allow the state to evaluate the potential impact of future GHG reduction measures.

The most recent inventory was completed by NCDEQ in January 2024, covering historical emissions from 1990 to 2020 and projecting future emissions through 2050 under a BAU scenario.[23] These projections assume no new federal or state policies beyond those in effect as of 2022 (e.g., Duke Energy's 2023 Carbon Plan/Integrated Resources Plan (CPIRP),[24] USDOT Corporate Average Fuel Economy (CAFE)[25] standards for cars and trucks). While the BAU projections do not include federal or state policy changes, when the inventory is updated again, the projections will address potential rollbacks of policies impacting GHG emissions.

The inventory is sector-based top-down approach, consistent with North Carolina's GHG inventory framework, and reflects major emissions sources including electric power generation, transportation, buildings, industry, agriculture, waste, and land use. Emission reductions modeled in the CCAP are assessed relative to this baseline.

The inventory will next be updated in 2026, and future CPRG reporting will incorporate these new data. Until then, the 2024 inventory and projections remain the reference for all CCAP strategies. The GHG reduction targets were established in Executive Order 80: North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy for NC. These targets align with those suggested by the U.S. government, regulated by EPA, which is committed to cutting GHG emissions by 50–52% below 2005 levels by 2030 and has set a goal of reaching net-zero emissions economy wide by 2050.[26]

2.1 Inventory Methodology

North Carolina's GHG inventory is a comprehensive assessment of statewide emissions sources and sinks, including historical emissions from 1990 to 2020 and BAU projections through 2050. The most recent inventory, completed in January 2024 by NCDEQ, serves as the foundation for this plan and reflects both historical trends and expected future emissions under a BAU scenario.

The inventory estimates emissions across all major sectors: electricity generation, transportation, buildings, industry, agriculture, waste, and land use, land-use change, and

[23] *North Carolina Greenhouse Gas Inventory (1990 – 2050). January 2024.* https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory

[24] https://starw1.ncuc.gov/NCUC/ViewFile.aspx?Id=cfc6d586-12e4-447f-a552-757d6e73c30e

[25] *USDOT, National Highway Traffic Safety Administration. Corporate Average Fuel Economy (CAFE) standards.* https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy

[26] *https://www.congress.gov/crs-product/R47385?utm*

forestry (LULUCF). It uses a combination of nationally recognized tools, sector-specific methodologies, and state-level data inputs.

NCDEQ applied internal quality assurance measures to evaluate consistency and accuracy, including cross-checks with other datasets and peer consultation on model assumptions. The final inventory enables state agencies, local governments, and stakeholders to benchmark emissions reductions, prioritize actions, and track progress toward North Carolina's climate goals.

The methods and tools used to prepare the NC GHG inventory are further described in Appendix A.

2.2 Inventory Results

North Carolina Department of Environmental Quality produces a statewide inventory of GHG emissions that represents North Carolina's "carbon footprint." The most recent inventory was completed in January 2024, covering historical emissions from 1990 to 2020 and projecting future emissions through 2050. These data serve as the baseline for evaluating the impact of the reduction measures proposed in this CCAP.

Figure 2 illustrates the distribution of gross GHG emissions by source sector for the year 2020, expressed in million metric tons of carbon dioxide equivalent ($MMTCO_2e$). In 2020, the Transportation sector was the largest source of emissions, accounting for 36% of the state's total. Electricity Generation and Use contributed 30%, and Residential, Commercial, and Industrial (RCI) Combustion accounted for 14%. Combined, combustion-related activities made up roughly 80% of North Carolina's total gross GHG emissions.

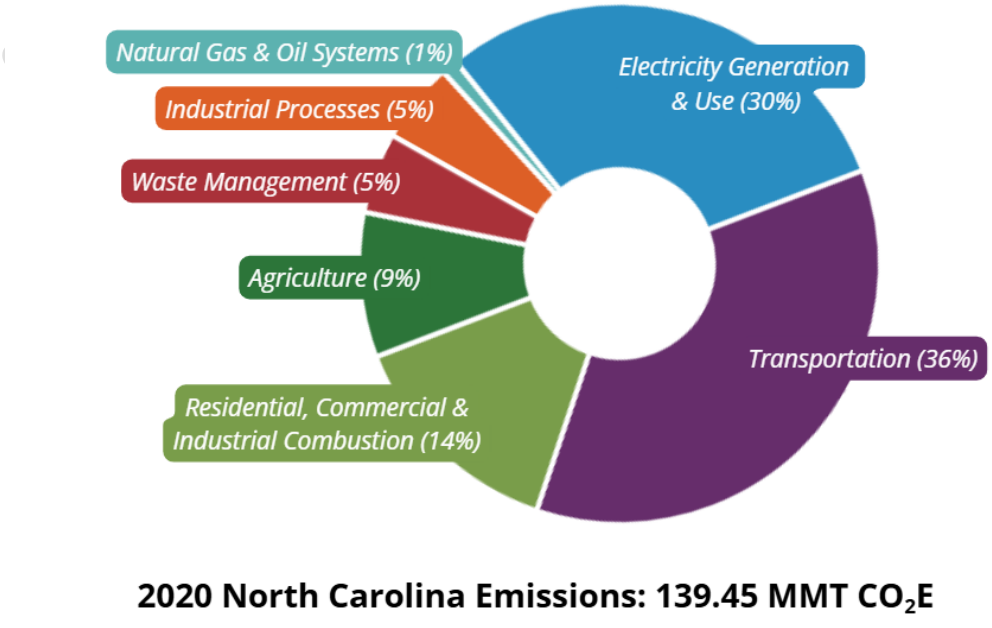


Figure 2. Percentage of North Carolina's 2020 Gross GHG Emissions by Source Sector

Table 1 provides the full historical and projected GHG emissions inventory for North Carolina by major source category. Historical emissions data span from 1990 through 2020, and projections extend through 2050 under a BAU scenario. Gross emissions in 2020 were approximately 139.45 $MMTCO_2e$, reflecting a 28% reduction from 2005 levels. When accounting for carbon sequestration (GHG offsets) from forests and other land uses (Natural Working Lands), net emissions in 2020 were 91.77 $MMTCO_2e$, a 38% reduction from 2005.

Table 2. Summary of NC's GHG Inventory and BAU Projections ($MMTCO_2e$)

Sector	Historical (Year)					Projected (BAU) (Year)			
	1990	2005	2010	2015	2020	2025	2030	2040	2050
Electricity Generation and Use[a]	55.39	82.66	82.98	58.58	41.77	43.08	26.71	14.08	8.50
Residential/Commercial/Industrial Combustion[b]	25.93	24.97	21.45	20.17	19.01	20.61	21.14	21.99	22.69
Transportation	42.68	58.56	58.45	58.47	50.35	54.10	52.07	43.55	35.84
Agriculture	9.06	12.63	12.21	12.54	12.46	12.31	12.46	12.87	13.28
Waste Management	5.56	7.21	7.98	5.99	7.17	7.35	7.48	7.74	7.99
Industrial Processes	1.25	4.87	4.98	6.56	7.22	8.54	9.00	9.53	10.12
Natural Gas and Oil Systems	1.18	1.53	1.62	1.39	1.48	1.65	1.65	1.65	1.65
Gross Emissions	**141.04**	**192.42**	**189.67**	**163.71**	**139.45**	**147.65**	**130.51**	**111.41**	**100.07**
Net Carbon Sinks - LULUCF[c]	-48.99	-45.08	-47.26	-48.29	-47.68	-47.23	-47.23	-47.23	-47.23
Net Emissions	**92.05**	**147.34**	**142.40**	**115.42**	**91.77**	**100.41**	**83.28**	**64.18**	**52.83**
Net Emissions Reduction from 2005					38%	32%	43%	56%	64%

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

[a] Includes estimates of emissions from Imported Electricity that are generated outside NC.

[b] Represents emissions associated with onsite fuel combustion activities in the Residential, Commercial, and Industrial sectors.

[c] Land Use, Land Use Change, and Forestry.

2.3 Inventory Trends and Analysis

North Carolina experienced a large decrease between 2019 and 2020, which is mostly attributable to a reduction in on-road vehicle emissions due to the COVID pandemic-related reductions in vehicle miles traveled (VMT). As indicated by Table 2 below, GHG emissions are expected to continue declining, with gross emissions projected to fall to 100.07 $MMTCO_2e$ by 2050. When netted with consistent land-based carbon sinks, net emissions are projected to reach 52.83 $MMTCO_2e$, representing a 64% reduction from 2005 levels.

Below are key findings from both the GHG emissions inventory and from the analysis of those data used to develop the emissions for each source sector. Unless otherwise stated, emission reductions are generally expressed as the percentage change in gross GHG emissions from the baseline year of 2005.

2.3.1 North Carolina's Greenhouse Gas Inventory – At-A-Glance

GHG Inventory Summary

Carbon Dioxide emissions currently account for nearly 79% of total GHG emissions in 2020

- Carbon dioxide emissions currently account for approximately 79% of total GHG emissions in 2020.
- The primary source of CO_2 emissions is fossil fuel combustion.
- GHG emissions from fossil fuel combustion have decreased by 33% between 2005 and 2020. This is due to both a shift in fuel use, from coal to natural gas and renewable generation resources, and increased energy efficiency.
- Methane emissions currently account for approximately 12% of total GHG emissions.
- The primary sources of methane are Waste Management and Agriculture.
- Emissions from Waste Management and Agriculture have not changed significantly since 2005, even with a growing population and economy.

NC's Gross and Net Emissions

Between 2005 and 2020, NC reduced gross GHG emissions by 28% and net GHG emissions by 38%

- During this same time, NC's population and real GSP grew by 20% and 23%, respectively.
- By 2030, net GHG emissions are forecast to decrease by 43% relative to the 2005 baseline.
- By 2050, net GHG emissions are forecast to decrease by 64% relative to the 2005 baseline.
- Although the COVID pandemic in 2020 caused a decrease in emissions on a short-term basis, projections show a rebound in GHG emissions in 2021, although lower than 2019 emissions.

Transportation

Represents the largest emissions sector and accounts for about 36% of all GHG emissions

- Emissions from the Transportation sector increased 1.14% from 2005 to 2019 emphasizing the need for further investments and reduction measures in this source category. 2020 Transportation sector emissions dropped; however, those emissions were atypically low because of the COVID pandemic.
- Emissions from the Transportation sector decreased by an estimated 14% from 2005 to 2020. However, 2020 was a year of atypically low emissions for many Transportation-emitting activities because of the COVID pandemic impact on personal travel.
- Onroad light-duty gasoline vehicles (LDV) represented 72% of total Transportation sector GHG emissions in 2019, while onroad medium/heavy-duty (MHD) diesel vehicles were the next largest contributor (16%).
- Following a recovery from the COVID pandemic and resumption of typical travel activities after 2020, the Transportation sector emissions projections showed an increase in 2021, but decreased thereafter reflecting the impact of onroad vehicle federal fuel efficiency and engine standards.

Electricity

Electricity Generation and Use is the second largest GHG emissions sector in 2020

- Electricity Generation and Use represents 30% of all gross GHG emissions in 2020.
- Electricity Generation and Use GHG emissions decreased by 49% since 2005.
- Solar, hydroelectric and wind energy represented 14% of NC's electricity generation in 2020.
- Avoided GHG emissions due to renewable energy generation are estimated at 5.24 $MMTCO_2e$ for 2020.
- Emissions from imported electricity in 2020 have decreased by 34% since 2005.
- GHG emissions in the Electricity Generation and Use sector are projected to decline by 68% in 2030 relative to 2005.

Residential, Commercial, and Industrial Combustion

These combustion emissions represent 14% of all GHG gross emissions

- Residential sector emissions from fuel combustion have decreased by 28% between 2005 and 2020, while NC's population grew by 20% over that time.
- Commercial sector emissions from fuel combustion decreased by 2.4% between 2005 and 2020.
- Industrial sector fuel combustion emissions decreased by 29% from 2005 to 2020.
- GHG emissions from Industrial Processes increased by nearly 50% from 2005 to 2020, mainly due to increased emissions of Hydrofluorochemicals (HFCs) and Perfluorochemicals (PFCs) resulting from their use as substitutes for ozone-depleting substances.

Natural and Working Lands (LULUCF)

Forests, natural lands, settlements, and agricultural lands sequestered an estimated 47.68 MMT of CO_2e or 34% of total gross GHG emissions in 2020

- Natural Working Lands (LULUCF) sector carbon sequestration is greater than estimated in the previous inventory, which reflects larger estimates of carbon stored in NC forests and Urban Trees (as estimated by the U.S. Forest Service (USFS)).
- Forests and settlement lands in NC are net sinks, and agricultural lands are a net source of emissions.

Table 3. Summary Table of Sector Emissions for 2005, 2010, 2015, and 2020

Sector	2005 Base Year Emissions ($MMT CO_2e$)	Interim Year 1 (2010) ($MMT CO_2e$)	Interim Year 2 (2015) ($MMT CO_2e$)	Most Recent Inventory Year (2020) ($MMT CO_2e$)
Electricity Generation	82.66	82.98	58.58	41.77
Commercial and Residential Buildings	24.97	21.45	20.17	19.01
Transportation	58.56	58.45	58.47	50.35
Agriculture	12.63	12.21	12.54	12.46
Waste and Materials Management	7.21	7.98	5.99	7.17
Industry	4.87	4.98	6.56	7.22
Natural Gas and Oil Systems	1.53	1.62	1.39	1.48
Natural and Working Lands	-45.08	-47.26	-48.29	-47.68
Total NET Emissions	**147.35**	**142.40**	**115.42**	**91.78**

2.4 BAU Projections Methodology

The NCDEQ projects the state's GHG emissions from 2021 to 2050 in a BAU scenario[27], based on forecasted changes in fuel use, population, historical trends, and other factors. The methods and tools used to prepare the NC GHG inventory are based on those used to prepare the national GHG inventory prepared by EPA annually, which is consistent with the 2006 Intergovernmental Panel on Climate Change Guidelines for National GHG Inventories. These methods are reflected in the U.S. EPA State Inventory and Projection Tool (SIT). The SIT includes default data supplied by EPA for North Carolina and other states. The default data are generally publicly available information from various federal agencies such as the U.S. Department of Energy (DOE), U.S. Department of Agriculture (USDA), Federal Highway Administration (FHWA), U.S. Geological Survey (USGS), U.S. Census Bureau, and EPA. For the Transportation sector, the latest version of EPA's MOVES was used to calculate historical and projected GHG emissions. BAU projected emissions are shown in Table 1 in the previous section.

BAU Projections Key Take Aways

Emissions are projected to decrease steadily after 2025, with 2030 gross emissions about 32% below 2005 levels and net emissions (accounting for carbon sinks) about 43% below 2005.

By 2050, gross GHG emissions are forecasted to be 48% lower than 2005 baseline levels, and net emissions 64% lower, reflecting impacts of state carbon plans and federal vehicle standards.

Electricity generation emissions are expected to decline sharply, while transportation emissions decrease more moderately. Agricultural and waste management emissions show slight increases or remain stable.

Natural Working Lands (e.g. Land use, land use change, and forestry (LULUCF)) provide significant carbon sinks, consistently offsetting roughly 47 $MMTCO_2e$ annually, which is critical in reducing net emissions.

[27] *North Carolina Greenhouse Gas Inventory (1990 – 2050). January 2024.* https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory

3 Short-Term and Long-Term GHG Reduction Targets

North Carolina has formal climate goals that collectively define the state's near- and long-term GHG reduction targets, which strongly align with those in the CPRG Program. These goals were established through executive orders, legislation, and sector-specific planning efforts since 2018, as shown in Figure 3 below. These goals may be impacted by future state or federal legislation.

Short-Term Target: Reduce economy-wide GHG emissions to 50% below 2005 levels by 2030.

Long-Term Target: Achieve net-zero economy-wide GHG emissions as soon as possible, but no later than 2050.

These goals are based on gross emissions for the 2030 target and on net emissions for the 2050 target, consistent with international practice.[28] North Carolina has also aligned these goals with health, economic, workforce and naturals benefits while encouraging local jurisdictions to conduct their own climate action planning.

[28] *Cooper, R (2022, January 7). Executive Order 246: North Carolina's path to clean, equitable economy. Office of the Governor. https://governor.nc.gov/executive-order-no-246/open.*

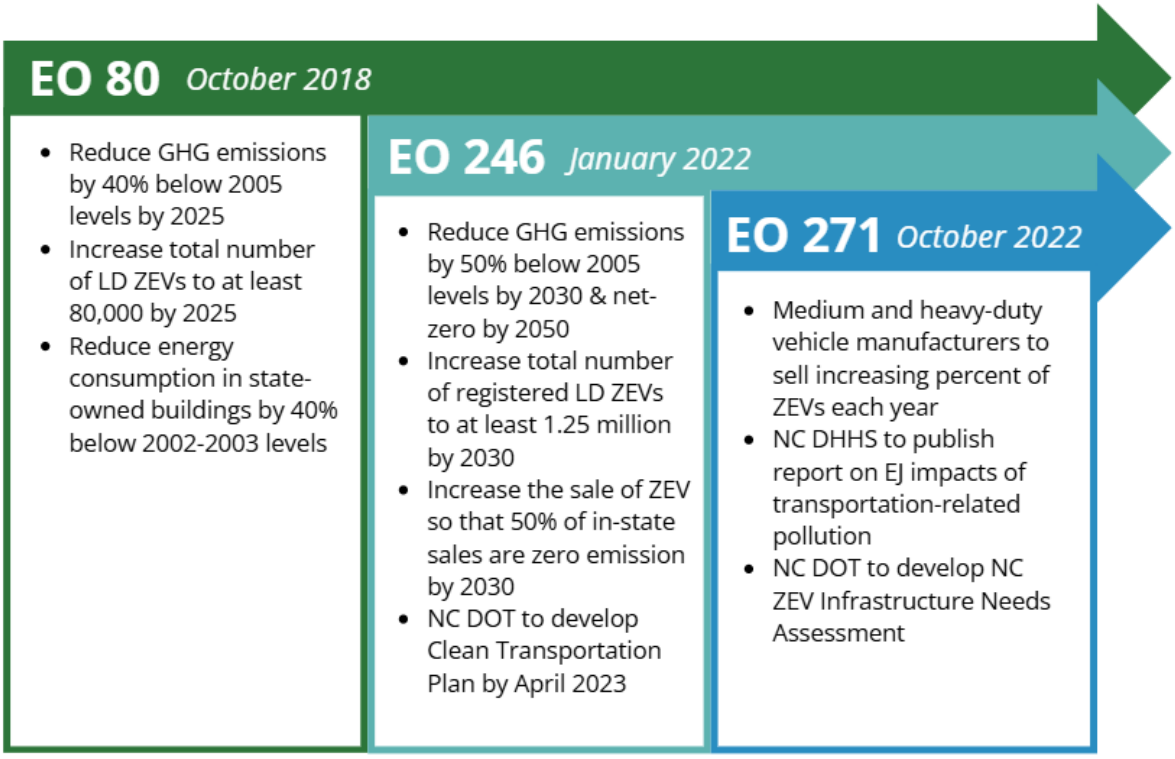
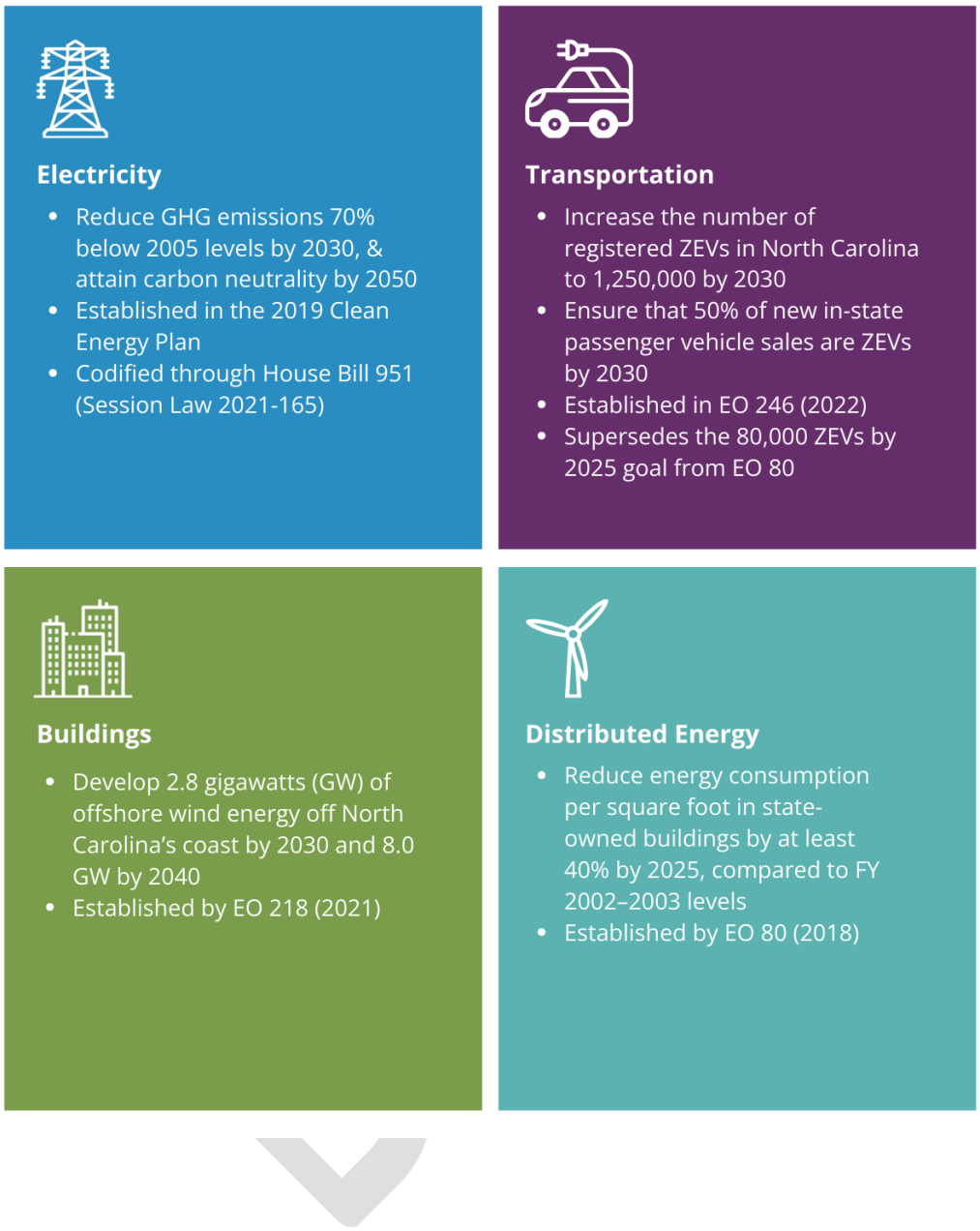


Figure 3. NC Key Policies for Reducing GHG Emissions

Additionally, in 2021, Governor Cooper signed SL 2021-1656 (HB 951)[29] a landmark bipartisan bill mandating 70% reductions in GHG emissions from North Carolina's power sector by 2030 and net-zero emissions by 2050. To enact this mandate, the Utilities Commission is instructed to retain discretion in determining the least cost path to compliance with these targets.

[29] https://www.ncleg.gov/BillLookup/2021/H951

Executive orders have set multiple sector-specific goals to reduce GHG emissions, as shown in Figure 4 .



North Carolina's GHG reduction targets are also congruent with the targets of local jurisdictions. Listed in Figure 5 are just a few cities that have GHG reduction targets listed in their Climate Action Plans:

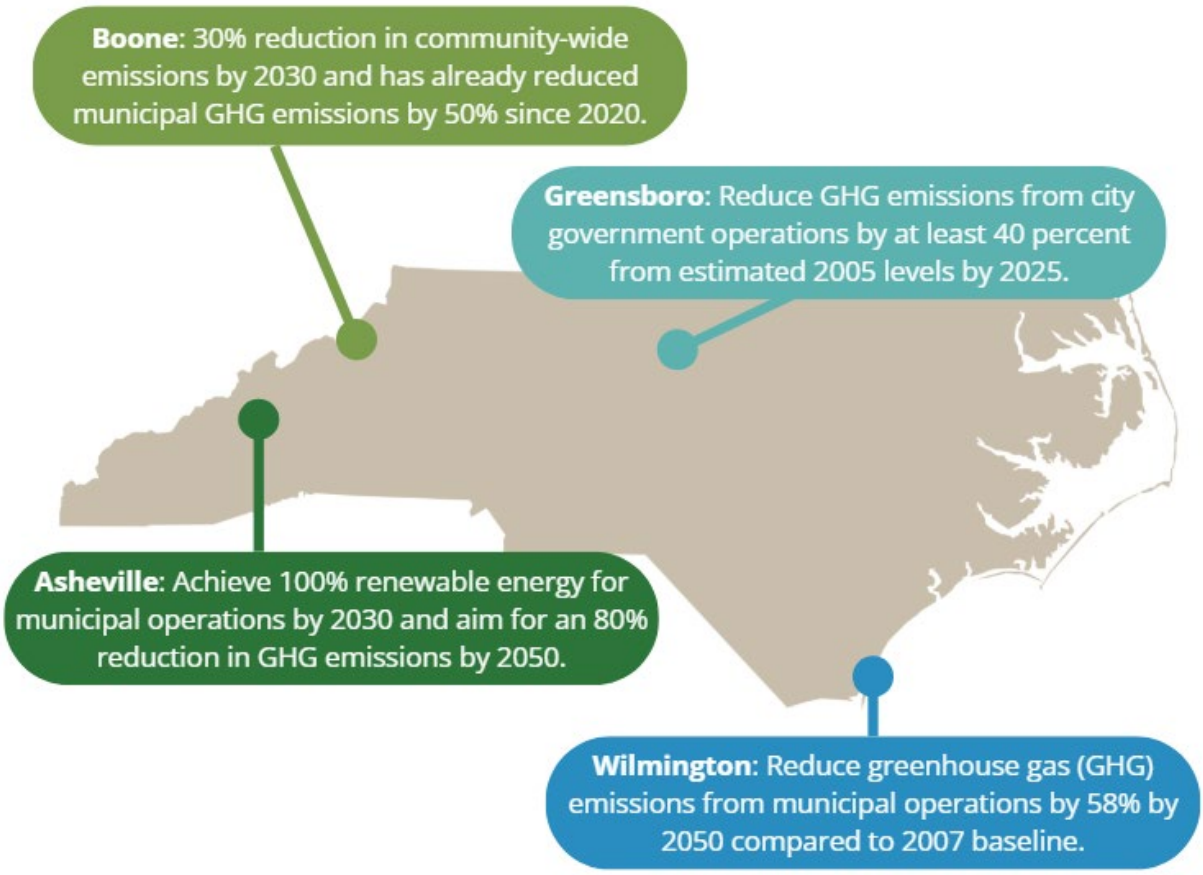


Figure 5. North Carolina GHG Reduction Targets in Local Jurisdictions

There are many benefits associated with reducing GHG emissions. Figure 6 describes some of the key benefits expected for businesses and residents of North Carolina.

Health

Reductions in GHG's results in reductions in other air pollutants like NOX, PM2.5 and SO2. These pollutants affect the respiratory and cardiovascular systems and especially affect people with asthma, particularly children.

Economy

Opportunities for residents to save money from converting to an electric vehicle, using solar power, and improving their homesteads by weatherizing and purchasing electric equipment are likely across the transportation, electricity and building sectors.

Workforce

Notably, clean energy jobs for workers are in high demand and are anticipated to continue especially those for the wind, solar, electric vehicle construction and repair and building efficiency (construction) sectors. The NC Department of Commerce estimated that an additional 10,000 jobs could be created by 2050 to support the clean energy economy.

Resiliency

Reducing GHG's improves resilience and reliability of NC's energy system, minimizing the economic and social toll of energy disruptions. By preventing or limiting the length of power outages, businesses avoid costly downtime, and residents maintain access to essential services. Resilient infrastructure will also enhance public safety, ensuring critical facilities like hospitals remain operational during crises, ultimately reducing mortality rates during extreme weather events.

Natural Working Lands

At least 70% of North Carolina's peatlands have been drained, which causes them to become carbon sources rather than carbon sinks and leads to land subsidence. Rewetting hydrologically altered peatlands helps to reduce CO2 emissions from degraded peatlands and helps to prevent soil loss and catastrophic fires that can endanger lives and property and release extensive GHGs. Restoring peatlands already in public ownership helps reduce these risks.

Figure 6. Key Benefits Associated with GHG Reduction

4 GHG Emission Reduction Measures for Key Sectors

This CCAP identifies a strategic set of 14 measures across six key sectors—Transportation, Electricity, Buildings, Industry, Waste, and Natural & Working Lands—that support North Carolina's long-term climate goals while responding to near-term opportunities. The measures reflect a mix of ongoing projects, planned efforts supported by existing programs, and emerging strategies that will inform future investment and policy decisions.

While no new implementation funding was provided under the CPRG Planning Grant, North Carolina leveraged this opportunity to build on the strong foundation established in its PCAP and the state's broader climate and clean energy efforts. CCAP measures represent feasible, measurable, and implementable sector-specific strategies to reduce GHG emissions and co-pollutants, improve public health and resilience, and support economic and environmental benefits across communities—especially those historically overburdened or underserved.

Measures were developed in alignment with CPRG guidance and in coordination with state agencies, local governments, ports, transit authorities, energy providers, and community-based organizations. They include a range of approaches, from expanding low-emission vehicle use and electrifying freight operations to advancing solar deployment, increasing energy efficiency in low-income housing, modernizing industrial operations, reducing methane emissions from landfills, and restoring high-carbon coastal ecosystems.

Though most measures are planning-focused or rely on non-CPRG funding sources, they are intended to guide future program development, funding alignment, and implementation partnerships. Together, these measures provide a realistic and opportunity-driven pathway toward a more sustainable, equitable, and climate-resilient North Carolina.

4.1 GHG Emission Reduction Measures Summary

The measures in Table 3 below are feasible, measurable, and implementable projects selected to achieve the state's climate goals while leveraging existing funding opportunities (e.g., DOE, DOT, and state funds). This is not an exhaustive list of North Carolina's climate priorities but represents selected key measures.

Table 4. List of Sectors and Measures

Sector	Measure	Description
Transportation	Measure 1	Increase the number of medium- and heavy-duty (MHD) zero emission and electric vehicles through programs to replace diesel emission vehicles.
	Measure 2	Identify, install, and maintain a public electric vehicle charging network to support increased EV adoption statewide.
	Measure 3	Implement programs to increase efficiency and reduce GHG emissions at deep water and inland ports.
	Measure 4	Support regional strategies to reduce vehicle miles traveled (VMT). (Unfunded)
Electricity	Measure 5	Increase the amount of electricity generated by renewable resources in North Carolina.
	Measure 6	Implement measures to increase energy resiliency in North Carolina communities: Microgrids for North Carolina Resilience.
Commercial & Residential Buildings	Measure 7	Reduce per square foot energy usage in residential buildings in North Carolina.
	Measure 8	Decarbonize buildings in North Carolina through replacement of fossil fuel combustion sources and other greenhouse gas emissions.
Industry	Measure 9	Industrial Decarbonization Planning and Opportunity Analysis. (Unfunded)
Waste	Measure 10	Reduce food waste entering the waste management system to reduce the methane emissions from food waste landfilling, direct food to communities in need, and create organic resources through composting or digestion.
	Measure 11	Decarbonize waste collection to reduce GHG emissions during the collection and transport of wastes through electrification of fleets or through engine conversion from diesel to electric motors.
	Measure 12	Reduce landfill gas emissions through improved landfill operations to collect gas more efficiently and earlier in a landfill life.
Natural Working Lands	Measure 13	Coastal Habitat Enhancement and Peatlands Restoration
	Measure 14	Protect, use, and develop agricultural and forest land.

4.2 Economy-wide Scenario Projections by Sector

This section presents North Carolina's projected GHG emission reduction trajectory if key measures identified in Section 4.3 are implemented. The implementation scenario reflects the anticipated emissions reductions from adopting feasible and fundable measures that are aligned with state climate goals, supported by stakeholder engagement, and backed by available policy or programmatic frameworks.

Overarching Key Takeaways:

These measures collectively aim to significantly reduce GHG emissions and enhance sustainability across various sectors, as shown in Table 4.

Table 5. Actions by Sector to Reduce GHG Emissions

Sector	Key Actions
Transportation	Increase low-carbon and electric vehicles by replacing diesel vehicles.
	Expand EV charging network to support EV adoption.
	Improve freight shipping efficiency by upgrading technology and expanding more efficient corridors
Electricity	Increase renewable energy through the promotion of solar, geothermal, and wind energy.
	Improve energy resiliency by Implementing microgrid solutions
Buildings	Reduce energy burden for low-income, rural households by offering rebates for insulation, air sealing, and HVAC upgrades.
	Increase energy efficiency in state-owned buildings through audits and upgrades.
Waste	Reduce methane emissions from landfills by diverting food waste, expand composting, and implementing gas collection systems and covers.
Natural and Working Lands (NWL)	Improve coastal and peatland restoration by protecting seashores and enhancing resilience.
	Promote climate-smart practices for sustainable forestry management.

The most recent inventory was completed by NCDEQ in January 2024, covering historical emissions from 1990 to 2020 and projecting future emissions from 2021 through 2050 under a BAU scenario.[30] Table 5 summarizes historic GHG emissions and Implementation scenario by sector. These data show that, with implementation of key measures, North Carolina can achieve its goal to reduce statewide GHG emissions by 50% from the 2005 baseline by 2030 driven largely by anticipated reductions in the electricity, buildings, and transportation sectors,

[30] *North Carolina Greenhouse Gas Inventory (1990 – 2050). January 2024.* https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory

along with continued land-based carbon sequestration. Achieving net-zero by 2050 is not attainable with the current projects and funding.

Table 6. Implementation Scenario Emissions by Sector

Sector	2005 Base Year Emissions (MMT CO_2e)	2020 Emissions (MMT CO2e)	Short-Term Implementation Scenario Year 2030 Emissions (MMT CO2e)	Long-Term Implementation Scenario Year 2050 Emissions (MMT CO2e)
Electricity Generation	82.66	41.77	26.35	7.98
Commercial and Residential Buildings	24.97	19.01	12.97	-12.80
Transportation	58.56	50.35	52.01	35.56
Agriculture*	12.63	12.46	12.46	13.28
Waste and Materials Management	7.21	7.17	6.21	5.97
Industry	4.87	7.22	9.00	10.12
Natural Gas and Oil Systems*	1.53	1.48	1.65	1.65
Natural and Working Lands	-45.08	-47.68	-43.87	-19.20
Total NET Emissions	**147.34**	**91.77**	**76.78**	**42.56**

*No measures were developed for this sector; GHGs reflect BAU projections for 2030 + 2050.

To estimate economy-wide GHG emission reductions, short-term and long-term emissions were calculated by subtracting the emission reductions estimated in each measure and totaled by sector from the BAU emissions shown in Table 1 for 2030 and 2050. The negative number shown in 2050 for Commercial and Residential Buildings sector is because the estimated emission reductions were greater than the BAU. Estimating emission reductions for 2050 introduces a large degree of uncertainty given that the economic landscape is ambiguous and assumptions like wide-spread EV adoption, shifts to renewable energy, and protection of natural habitat may not occur at the predicted rates. Additional challenges include declines in key labor sectors for building construction, which may impact the gains estimated for the Commercial and Residential Buildings sector.

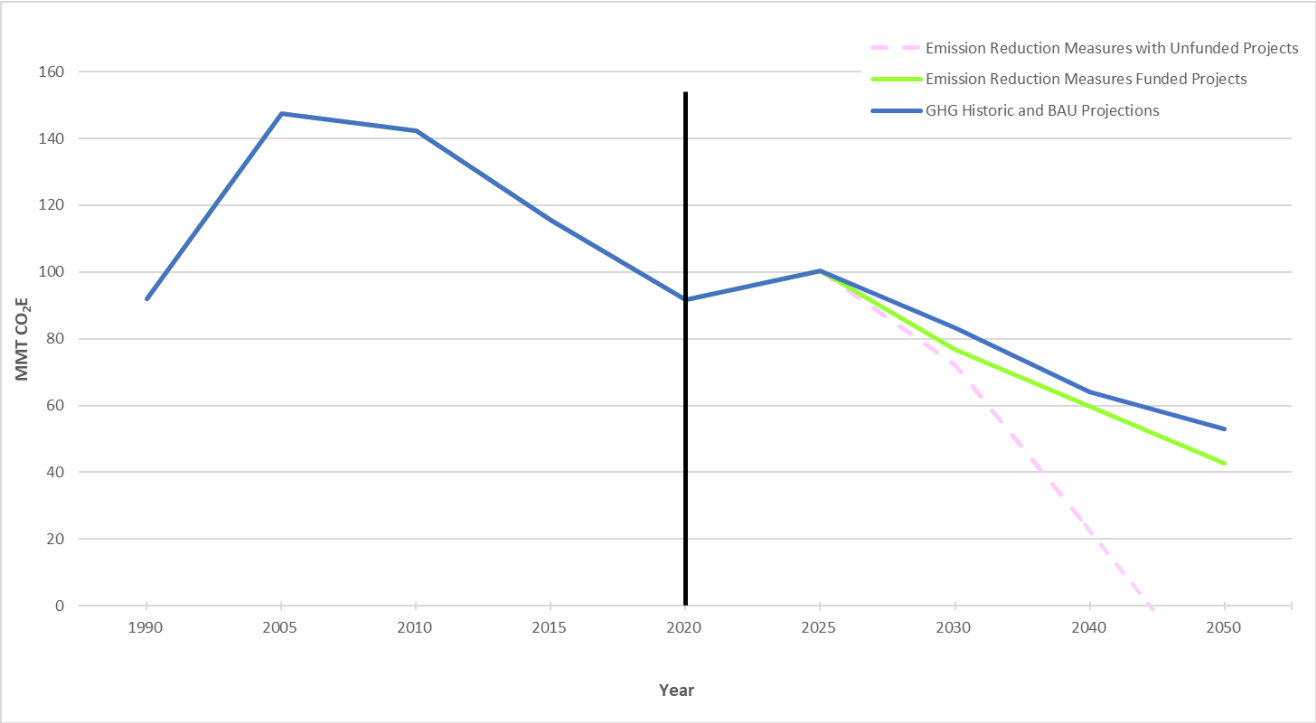


Figure 7. Historical and projected economywide GHG emissions

Figure 7 above shows the economy-wide historical GHG emissions to the left of the vertical black line in the year 2020. The lines to the right of the black line, starting in the year 2020, indicate the following:

- The blue line indicates the BAU projections described in Section 2. This represents the GHG emission trajectory with no additional measures.
- The green line indicates the GHG emission reductions if the measures described in Section 4-3 are implemented.
- The pink dashed line shows the GHG emission reduction *potential* that could be achieved if the unfunded CCAP projects had received money. In this scenario, net-zero emission could be achieved around 2045.

4.3 North Carolina's Key GHG Emission Reduction Measures

The sections below describe a suite of key GHG reduction measures that together provide North Carolina a framework to achieve the target GHG emission reduction goals for 2030 and 2050. The measures included in these sections are not exhaustive but are collectively impactful and provide feasible, measurable, and implementable actions that may provide local jurisdictions the opportunity to create similar plans or to implement similar actions.

4.3.1 Implementation Authority Overview

To support the planning framework established in this CCAP, NCDEQ compiled a summary of implementation authorities across all 14 GHG emission reduction measures. This summary identifies the lead and supporting entities that hold the legal authority, operational capacity, or programmatic expertise to carry out the types of actions outlined in each measure.

Figure 8 below identifies implementation authority for sector measures. It is organized by sector and measure number and includes:

- The **lead agency** directs or oversees implementation,
- **Supporting entities** contribute expertise, outreach, or technical assistance, and
- The **legal authority** is the statutory framework underpinning that role.

The intent of this figure is to provide transparency about where institutional responsibility currently exists. In many cases, authority is grounded in existing statutory frameworks, executive orders, programmatic roles, or regulatory permitting structures.

The Implementation Authority Figure, Figure 8, is presented in summary form to avoid repeating detailed agency and statutory references under each measure. The figure reflects the current institutional landscape and is subject to refinement as federal and state programs evolve. It serves as a planning tool to support future funding readiness, interagency coordination, and ongoing climate program development.

Transport

ZEVs, ports, & infrastructure

Measures 1-4

Lead agencies: NCEQ; NCDOA; NCDOT; NC State Ports Authority; MPO

Supporting entities: Private; LGO; State ; NCCEF; NCCETC; Advanced Energy

Legal Authority: EOs 80, 246, 271; VW Settlement, EPA Order § 5700,5A1; Assistance Listing 66.039; Freight & Rail Plans; LPO/MPO

Electricity

Renewables and resilience

Measures 5 & 6

Lead agencies: NCDEQ

Supporting entities: NCDEMLR; NCCCEF; Advanced Energy; NCCETC; Land of Sky; NC Sustainable Energy; FootPrint

Legal Authority: EOs 80 and 246

Buildings

Residential & commercial

Measures 7 & 8

Lead agencies: NCDEQ

Supporting entities: WAP subgrantees; Energy Saver NC; state agencies and universities

Legal Authority: DOE WAP regulations; SEO program authority; GS § 143-65.12

Industry

Energy efficiency

Measure 9

Lead agencies: NCDEQ

Supporting entities: Private industry

Legal Authority: None

Waste

Diversion, gas collection & landfills

Measures 10-12

Lead agencies: NCDEQ

Supporting entities: LGO, private sectors

Legal Authority: GS §§ 130A-309.04, .09B, .10, .11

Natural & Working Lands

Coastal and forest preservation

Measures 13 & 14

Lead agencies: DNCR

Supporting entities: NCCF, NCFS, The Nature Conservancy, Roanoke Cooperative's Sustainable Forestry and Land Retention Project

Legal Authority: GS Article 2 § 143B135.12; GS Chapter 106 Article 83; regulatory authority for projects through permit authorizations; NGO or non-profit missions

Figure 8. Implementation Authority and Lead Agencies

4.3.2 Sector 1 Transportation Measures 1-4

North Carolina's transportation sector accounted for approximately 36% of statewide GHG emissions, or 50.35 $MMTCO_2e$, according to the state's latest GHG inventory.[23] Approximately 72% of transportation emissions were attributable to light-duty internal combustion engine on-road vehicles.

Under a BAU scenario, transportation emissions in North Carolina are projected to rise to 52.01 $MMTCO_2e$ by 2030, before falling to 35.56 $MMTCO_2e$ by 2050 due to anticipated electric vehicle (EV) adoption, cleaner fuel standards, and vehicle emission regulations. However, further emissions reductions could be achieved through strategies that reduce GHG emissions from key transportation sources, as described in Measures 1-4 below.

NCDEQ developed and modeled GHG emission reductions for short-term (2030) and long-term (2050) timeframes. Table 6 shows the total estimated reductions for each timeframe by measure and sector. Compared to the BAU projections, these measures will reduce GHG emissions from the transportation sector by 0.1% by 2030 and 0.8% by 2050. Additionally, Table 7 includes measures that were not funded; however, NCDEQ developed and modeled GHG emission reductions in the PCAP and included them here to highlight the GHG emission reductions potential that could be realized with additional resources.

Transportation Key Take Aways

NCDEQ has developed and modeled three transportation measures that collectively will reduce GHG emissions by 0.1% by 2030 and 0.8% by 2050. These measures include:

Increase the number of low-carbon emitting and electric vehicles like school buses, transit buses, garbage trucks, emergency vehicles, and off- and on-road construction vehicles with approximately $83 million to replace diesel emission vehicles resulting in GHG reductions of 37,339 MTCO2e by 2030 and 186,696 MTCO2e by 2050.

Expand the public electric vehicle charging network with about $14 million to support increased EV adoption statewide results in 15,151 MTCO2e by 2030 and 75,754 MTCO2e by 2050.

Improve energy efficiency associated with freight shipping at NC ports by upgrading technology at freight terminals and ports, expanding more efficient freight corridors across the state, and coordinating with private industry to increase electrification of equipment. Actions result in 11,448 MTCO2e by 2030 and 18,078 MTCO2e by 2050 at a total cost of over $117 million.

Table 7. Total GHG reductions in $MTCO_2e$ that can be implemented through Measures 1-3.

Measure Number and Abbreviated Title	Short-Term Implementation Scenario Year 2030 Emissions ($MTCO_2e$)	Long-Term Implementation Scenario Year 2050 Emissions ($MTCO_2e$)
1 – Medium & Heavy-duty vehicles	37,339	186,696
2 – EV Infrastructure	15,337	76,684
3 - Ports	11,448	18,078
Total		**281,458**

Table 8. Total GHG reductions in MTCO2e for Measure 2 and Measure 4 (unfunded).*

Measure Number-Title	Short-Term Implementation Scenario Year 2030 Emissions ($MTCO_2e$)	Long-Term Implementation Scenario Year 2050 Emissions ($MTCO_2e$)
2 – EV Adoption	2,570,000	58,800,000
4 – Bike / Ped Infrastructure	4,000	20,000
Total	**2,574,000**	**58,820,000**

*This table shows the GHG reductions that would be achieved if these measures received funding.

Implementation Authority

See Figure 8 Implementation Authority and Lead Agencies.

Measure 1. Increase the number of medium- and heavy-duty (MHD) low-carbon emitting and electric vehicles through programs to replace diesel emission vehicles.

Accelerating the widespread adoption of low-carbon emitting and electric vehicles (EVs) that replace higher carbon emitting vehicles will translate into emission reductions from everyday use of on-road vehicles. This measure includes activities that support a multifaceted approach to achieving the state's vehicle electrification priorities. Vehicles in this program include school buses, transit buses, garbage trucks, emergency vehicles, and off- and on-road construction vehicles. Outlined in this strategy are actions for three programs that focus on replacing MHD

vehicles with low-carbon emitting and electric vehicles: the Volkswagen (VW) Settlement[31], the Diesel Emission Reduction Act (DERA)[32], and the Clean Fuels Advanced Technology (CFAT)[33] program. A short description of each follows.

Measure 1-1 Volkswagen (VW) Settlement

In 2015, the U.S. Environmental Protection Agency (EPA) found that Volkswagen had installed illegal "defeat devices" in certain diesel vehicles to cheat emissions tests. These illegal software programs made the cars appear to meet federal nitrogen oxide (NOx) limits during testing, but in real-world driving they emitted much higher levels of pollution. The violations affected both 2.0-liter and 3.0-liter diesel models sold between 2009 and 2016.

The U.S. Department of Justice took legal action, resulting in settlements that required Volkswagen to pay billions of dollars nationwide. Under EPA compliance of this agreement[34], every state, including North Carolina, received funding to reduce NOx emissions from diesel vehicles and to build charging stations for zero-emission vehicles. This funding is being invested over a ten-year period to help improve air quality and support cleaner transportation options.[35]

Through the North Carolina Volkswagen Settlement Program,[36] NCDEQ-DAQ awarded more than $76 million to support a variety of projects designed to replace diesel emission vehicles. Altogether, 57% of the funding went to projects in rural counties. Of the 423 vehicles replaced, 76 were replaced with new all-electric equipment, using more than 47% of funding for these programs (see Table 8). Awards for clean diesel, propane, clean natural gas, and biofuel were also made. These projects combined will prevent more than 30,359 $MTCO_2e$ from being emitted into the atmosphere. These projects will also reduce particulate matter, carbon

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[31] *North Carolina Department of Environmental Quality. (2025). Mobile Sources Emissions Reductions Grant. NC DEQ. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/volkswagen-settlement-clean-vehicle-replacements.*

[32] *North Carolina Department of Environmental Quality. (2025). Mobile Sources Emissions Reductions Grant. NC DEQ. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/mobile-sources-emissions-reductions-grant.*

[33] *Piedmont and Coastal North Carolina. (2018). Learn More About New Air Quality Improvement Grant Projects. https://www.fuelwhatmatters.org/learn-more-about-new-air-quality-improvement-grant-projects/.*

[34] *U.S. Environmental Protection Agency, (2015, September 18). Notice of Violation: Clean Air Act – Volkswagen AG, Audi AG, and Volkswagen Group of America, Inc. https://archive.epa.gov/epa/sites/production/files/2015-10/documents/vw-nov-caa-09-18-15.pdf .*

[35] *U.S. Department of Justice. (2016, June 28). Volkswagen to spend up to $14.7 billion to settle allegations of cheating emissions tests and deceiving customers on 2.0-liter diesel vehicles. Office of Public Affairs. https://www.justice.gov/archives/opa/pr/volkswagen-spend-147-billion-settle-allegations-cheating-emissions-tests-and-deceiving.*

[36] *NC VW Grant Program. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement*

monoxide, and hydrocarbons. Since 2018, NCDEQ has obligated over 90% of the funds and expended approximately 70% of available program funds.

Implementation Timelines and Milestones

The VW Settlement was divided into two phases of funding (see Figure 9 and Figure 10):

- Phase 1: $30.68 million (33% of overall funds)
- Phase 2: $61.36 million (67% of overall funds)

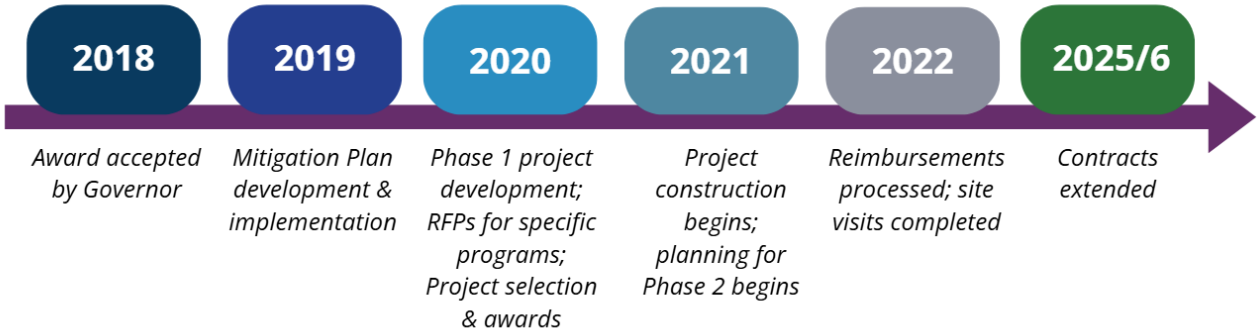

Figure 9. Phase 1 - Implementation Timeline and Milestones

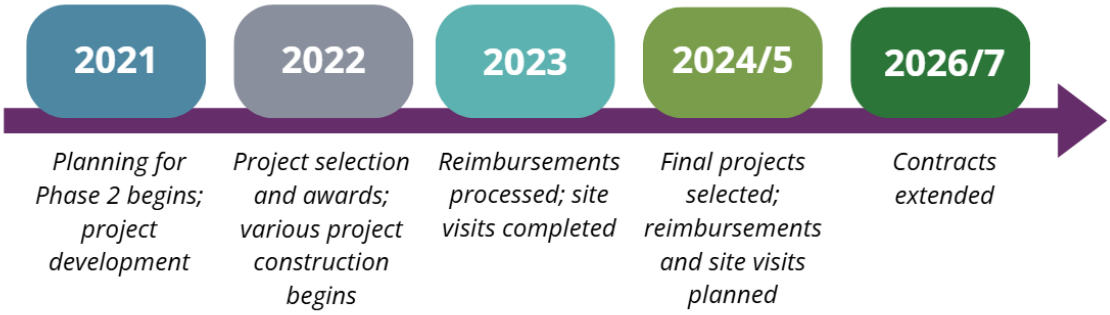

Figure 10. Phase 2 - Implementation Timeline and Milestones

Metrics for Tracking Progress

Progress is tracked for the VW project through quarterly reporting that includes number of vehicles replaced and those destroyed with photographic evidence, funds expended for the time period and remaining funds NCDEQ has until project funding is exhausted. Upon project completion, grantees are required to submit a final report to NCDEQ. NCDEQ must submit semiannual reports summarizing program progress to the Volkswagen Diesel Emissions Environmental Mitigation trustee in January and July until the VW Settlement work is complete. Vehicles replaced are tallied below in Table 8.

Table 9. Vehicles Replaced under NC VW Program

Vehicle Type	Number Replaced	All-electric*
School buses	271	48
Transit and shuttle buses	64	24
Heavy-duty and equipment vehicles	88	4
Total	423	76

*All-electric replacement account for 86% of GHGs reduced.

Measure Costs

The costs reflected in Table 9 are for the VW Settlement Program.

Table 10. Costs for VW Settlement

Measure No.	Title	Funded Amount	Matching Funds*
1-1	School Bus program	$41,993,715	$897,113
	Transit & Shuttle program	$19,650,832	$3,189,980
	Clean Heavy Duty program	$15,173,23	$794,223

*Matching funds are from the organization that applied for funding.

For awardees, there are several unexpected costs that could be associated with low-carbon emitting vehicles and/or EVs after VW projects have been completed. Potential costs include:

- Fluctuating electricity rates
- Uncertain depreciation
- Scheduled maintenance and repair costs
- More tire wear
- Higher insurance premiums
- Battery capacity loss
- Training to operate ZEVs

Intersection with Other Funding Availability

Projects in the VW Mitigation program were reimbursed with State-allotted mitigation funds. Awardees can contribute matching organizational funds to make projects cost effective in terms of VW funds spent, as well as seek additional outside funding sources to help compensate for overall project costs.

Measure 1-2. Diesel Emission Reduction Act (DERA)

The "Diesel Emissions Reduction" program was originally proposed as the Diesel Emissions Reduction Act of 2005 by Senator Thomas Carper (DE) and the late Senator George Voinovich (OH) in June 2005.[37] It was favorably voted out of the Environment and Public Works (EPW) Committee in September of that year and incorporated into The Energy Policy Act of 2005, thereby creating a financial assistance program dedicated to reducing diesel emissions – known as DERA.[38] Enjoying bi-partisan support, the Diesel Emissions Reduction Act of 2010 reauthorized the program in early 2011. Most recently, in 2020, current EPW Committee Chairman Carper led the latest provisions which reauthorized DERA through fiscal year 2024.[39] EPA's Office of Transportation and Air Quality administers the DERA program. Funding opportunities for diesel emissions reduction projects are provided through an annual appropriation by Congress to DERA. EPA is authorized under DERA to offer funding assistance to accelerate the upgrade, retrofit, and turnover of the legacy diesel fleet. North Carolina receives funding from the EPA to mitigate NOx emissions from MHD vehicles in North Carolina.

Since 1995, the NCDEQ DAQ has offered individuals, businesses, and organizations DERA funding to help cover the costs of their emission reduction projects. These projects include diesel engine replacements, diesel oxidation catalyst retrofits, marine diesel repowers, and many more.[40]

There are DERA projects that were awarded prior to March 1, 2024, that have not yet been completed. These projects are still eligible for reimbursement after DAQ requested an

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[37] *U.S. Senate Committee on Environment and Public Works. (2005, July 12). S. 1265, the Diesel Emissions Reduction Act of 2005: Hearing before the Subcommittee on Clean Air, Climate Change, and Nuclear Safety of the Committee on Environment and Public Works, United States Senate, One Hundred Ninth Congress, First Session. U.S. Government Printing Office. https://www.govinfo.gov/content/pkg/CHRG-109shrg37294/pdf/CHRG-109shrg37294.pdf.*

[38] *Federal Energy Regulatory Commission. (2005). Fact sheet: The Energy Policy Act of 2005. U.S. Government. https://www.ferc.gov/sites/default/files/2020-04/epact-fact-sheet.pdf.*

[39] *U.S. Senate Committee on Environment and Public Works. (2020, July 23). Senate approves bipartisan DERA reauthorization in NDAA. https://www.epw.senate.gov/public/index.cfm/2020/7/senate-approves-bipartisan-dera-reauthorization-in-ndaa.*

[40] *Mobile Sources Emissions Reductions Grant. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/mobile-sources-emissions-reductions-grant*

extension due to issues with supply chain and project operations. This extension will allow DAQ additional time to achieve the goals in the work plan.

Implementation Timelines

For 2024, approximately $1.1 million is available in the program to replace diesel vehicles, and projects are underway. See the implementation timeline below in Figure 11.

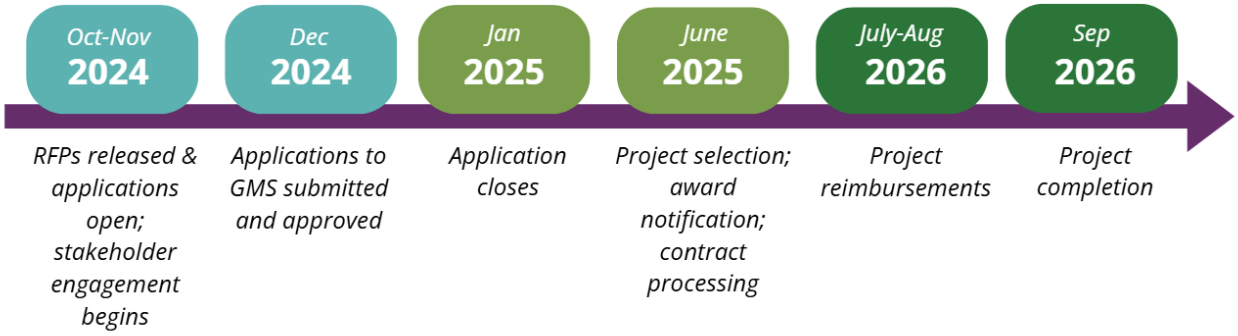

Figure 11. DERA Implementation Timeline

Metrics for Tracking Progress

Progress for the DERA projects is tracked in a similar manner to the VW project for grantees. NCDEQ is required to submit quarterly reports summarizing program progress and costs to EPA until the DERA work for an awarded DERA cycle is complete. Quarterly reports must be submitted within 30 days after the end of each reporting month. Additionally, a final report must be submitted to EPA within 120 days of the end of the awarded DERA cycle or when the final project awarded from that cycle is completed.

Measure Costs

Costs for Measure 1-2 are detailed below in Table .

Table 11. Costs DERA

Measure No.	Title	Funded Amount	Matching Funds*
1-2	DERA Program	$1,501,100	$2,031,525

*Matching funds are from the organization that applied for funding.

Measure 1-3 Clean Fuels Advanced Technology (CFAT)

The North Carolina Clean Energy Technology Center (NCCETC) at North Carolina State University (NCSU) provides grants through the Clean Fuels Advanced Technology (CFAT) project with the primary purpose of reducing transportation-related air emissions, specifically nitrous oxide (NOx).[41] The second purpose of CFAT is to expand the availability of EV charging infrastructure. Funding for electric vehicle charging stations (EVSE) infrastructure for eligible Level 2 (AC) and DC Fast Chargers is available in all 100 counties of North Carolina.[42]

The 2025 CFAT initiative will offer $5.9 million in grant funding, supported by federal Congestion Mitigation Air Quality (CMAQ) funding from the NCDOT and the Federal Highway Administration (FHWA).[43] Project funding will be limited to a maximum award of $450,000 with a minimum award of $5,000.

Eligible projects include alternative fuel vehicles (biodiesel, E-85 ethanol, electric, hybrid electric, natural gas, and propane) and refueling and recharging equipment. Additional projects eligible for funding include vehicle telematics, electric truck stop parking projects, auxiliary power units, diesel and propane retrofits, and idle reduction technologies.

Implementation Timeline and Milestones

Request for Proposals (RFP) for the 2025 CFAT program closed on April 18, 2025. CFAT projects considered during this program cycle include both transportation emission reduction and EVSE charging infrastructure projects. The projects granted funding began July 1, 2025, and will receive funding until June 30, 2027. For the 2025 CFAT program cycle, see Table .

[41] *North Carolina Clean Energy Technology Center. (2025). Advancing a clean energy economy. North Carolina State University. https://nccleantech.ncsu.edu/.*

[42] *NC Clean Energy Technology Center. (2025). Clean Fuel Advanced Technology (CFAT) Project Grant Funding. North Carolina State University. https://nccleantech.ncsu.edu/our-work/center-projects-old/cfat-project-request-for-proposals-information/.*

[43] *NC Clean Energy Technology Center. (2025, January 10). 2025 Clean Fuel Advanced Technology (CFAT) Project Grant Funds Available Now. North Carolina State University. https://nccleantech.ncsu.edu/2025/01/10/2025-clean-fuel-advanced-technology-cfat-project-grant-funds-available-now/.*

Table 12. 2025 CFAT Timeline and Milestones

Action	Timeline	Milestones
Deadline for 2025 CFAT Program Cycle	April 18, 2025	All RFPs for 2025 CFAT funding must be submitted to review.
CFAT Program Cycle	July 1, 2025 – June 30, 2027	CFAT projects will begin on 7/1/25 and receive funding until 6/30/27

Metrics for Tracking Progress

For the CFAT measure, all projects must result in emission reductions in eligible areas. To calculate emissions benefits, all projects must provide:

- estimated number of miles to be driven,
- vehicle year/make/model to be replaced and/or converted to operate on natural gas or propane (or repowered in cases of diesel retrofits),
- vehicle(s) and emissions certification and/or relevant testing data,
- the number of gallons of fuel equivalents, and
- gasoline gallon equivalents, or kWh consumption estimates for vehicles driving in eligible areas (for refueling/recharging infrastructure applications).

Quarterly and final reports that demonstrate key implementation milestones achieved and data on fuel usage, idling reduction, emissions reduction, and other important benefits of the project. Final reports must include a minimum of 12-24 months of actual data.

Annual reporting to relevant Clean Cities and Communities coalition in NC that includes total amount of alternative fuels used by the project's fleet (including electricity for electric vehicles), total number of alternative-fuel vehicles, and information on idle reduction policies and technologies used.[44]

Measure Costs

Each subgrantee must provide a minimum cost share of 20-24% of total project costs. Cost share funds must be non-federal dollars and must be directly related to the project. Each project has a minimum award of $5,000 and a maximum award of $450,000.

[44] *Land of Sky Regional Council. (2021, March). 2020 Transportation Technology Deployment Report: Land of Sky Clean Vehicles Coalition (Western North Carolina).* *https://landofsky.org/pdf/LGS/CleanVehicles/CleanCities_LOSRC_AR2020.pdf*.

NCCETC will reimburse expenses directly related to the project such as equipment purchases, leases, installation, commissioning, operation and maintenance costs. However, fuel and electricity and planning/administration costs are not eligible expenses.

Intersection with Other Funding Availability

There are no additional funding options for the CFAT program.

Quantified GHG Emission Reduction for Measure 1

Both the VW and DERA programs have calculated a variety of emissions reductions over the remaining life of vehicles for their awarded projects, presented in Table 13. While NOx reductions are the main focus of these programs, GHG reductions are estimated using the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool and the Deisel Emissions Quantifier. Calculations start in 2025 and are projected to 2050.

Table 13. Measure 1 GHG Emission Reductions (MTCO2e)

Measure No.	Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
1-1	School Bus program	9,272	46,360
	Transit & Shuttle program	14,068	70,340
	Clean Heavy-Duty program	7,025	35,126
1-2	DERA program	3,474	17,370
1-3	CFAT (2022 cycle)**	3,500	17,500
	TOTAL for Measure 1*	37,339	186,696

*GHG reductions reflect the totality of the VW program, while the DERA reductions reflect only projects from 2024.
** GHG reductions are from the 2022 cycle only and may not reflect emissions realized for future projects or projections to 2050.

For the CFAT projects for the 2025 cycle are in process and GHG emission estimates will be provided in future monitoring reports.

Measure 2. Identify, install, and maintain a public electric vehicle charging network to support increased EV adoption statewide.

Complementary to the increase in EVs will be investments in EV charging infrastructure. This measure aims to advance the expansion of an EV charging network across NC to support the widespread adoption of EVs.

The VW Settlement included a provision to expand EV charging infrastructure across NC. NCDEQ accomplished this by providing funding for EV chargers at strategic locations across the state with 2 main programs.[45] Funds were awarded for two types of chargers: DC Fast chargers and Level 2 chargers.

The DC Fast program provided grant funding for eligible projects that would install qualifying light-duty EVs supply equipment.[46] Funding awards were based on charging capacity, the number of ports, and type of applicants (government or non-government). DC Fast chargers offer rapid charging and are suitable along major highways because they allow drivers to quickly continue to their destination. On October 15, 2024, NCDEQ released the RFP for the Community and Destination Zero Emission Vehicle Infrastructure Program.[47] This program's $1,890,605 available funds for new DC Fast charging looks to enhance and extend the current EV infrastructure network to communities and destinations that are not located on the designated Alternative Fuel Corridors (AFC). To date NCDEQ has funded 163 new DC fast ports at 82 sites across the state. These projects will prevent 3,889 $MTCO_2e$ from entering the atmosphere by 2030.[48]

In the Level 2 program, the NCDEQ primarily issued funds for Level 2 chargers through rebates on a first-come, first-served basis. This program was designed to expand the state's light duty EV charging infrastructure network. Level 2 chargers were installed at workplaces, apartment complexes, parks, urban centers, state attractions, businesses, parking decks, libraries and other locations where a vehicle would be parked and could charge for several hours. In total,

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[45] *NCDEQ VW Settlement. EV Charging Infrastructure. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/volkswagen-settlement-ev-charging-infrastructure#DCFastProgram-14323*

[46] *North Carolina Department of Environmental Quality. (n.d.). Volkswagen Settlement: EV charging infrastructure. NC DEQ. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/volkswagen-settlement-ev-charging-infrastructure.*

[47] *North Carolina Department of Environmental Quality. (2024, October 15). Volkswagen Settlement Community and Destination Zero-Emission Vehicle Infrastructure Program. Division of Air Quality. https://www.deq.nc.gov/news/events/volkswagen-settlement-community-and-destination-zero-emission-vehicle-infrastructure-program.*

[48] *North Carolina Department of Environmental Quality. (n.d.). Volkswagen Settlement DC Fast Electric Vehicle Charging Awards. Division of Air Quality. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/volkswagen-settlement-ev-charging-infrastructure/volkswagen-settlement-dc-fast-electric-vehicle-charging-awards.*

NCDEQ has provided funding for 839 Level 2 ports at 240 sites across the state. These projects will prevent more than 11,448 $MTCO_2e$ from entering the atmosphere.[49] Table 13 provides the projected GHG emission reductions from these and other programs under Measure 2. Measure 2 costs are provided below in Table 14.

Absent from this measure are ways in which to incentivize the adoption of electric light-duty vehicles, which were proposed in EO 246 and the PCAP.[50] In EO 246, the Governor directed that the total number of registered EVs be increased to at least 1,250,000 by 2030 and increase the sale of EVs so that 50% of in-state sales of new vehicles are zero-emission by 2030. Overall, EV adoption in North Carolina has been increasing since the executive order was announced; and adoption is expected to continue without funding. This continued adoption in the absence of funding will be bolstered by the increases in charging infrastructure as discussed above. The Clean Vehicles Coalitions[51] across North Carolina work with vehicle fleets, fuel providers, community leaders and other stakeholders to save energy and promote the use of domestic fuels and advanced vehicle technologies in transportation, including investments in EVs and associated charging infrastructure. Conservatively, in 2030, this measure could reduce GHG emissions by 2.57 $MMTCO_2e$, and in 2050, emissions could be reduced by 58.8 $MMTCO_2e$ if EV adoption continues increasing as hoped. However, EV adoption is not feasible, implementable or measurable without funding, especially in rural areas of North Carolina where infrastructure and workforce support is absent.

Implementation Timelines and Milestones

The overall timeline and milestones for the VW Settlement projects are described in Section 5, Measure 1.

Metrics for Tracking Progress

The overall metrics for tracking progress for this Measure are described in Section 4, Measure 1.

[49] *North Carolina Department of Environmental Quality. (n.d.). Volkswagen Settlement DC Fast Electric Vehicle Charging Awards. Division of Air Quality. https://www.deq.nc.gov/about/divisions/air-quality/motor-vehicles-and-air-quality/volkswagen-settlement/volkswagen-settlement-ev-charging-infrastructure/volkswagen-settlement-dc-fast-electric-vehicle-charging-awards.*

[50] *Cooper, R (2022, January 7). Executive Order 246: North Carolina's path to clean, equitable economy. Office of the Governor. https://governor.nc.gov/executive-order-no-246/open.*

[51] *Centralina Regional Transit Council, Land of Sky Clean Vehicles Coalition, and Triangle Clean Cities Coalition.*

Quantified GHG Emission Reduction

Table 14. Measure 2 GHG Emission Reductions (MTCO2e)

Program Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
DC Fast Program	3,889	19,466
Level 2 Programs	11,448	57,239
Total for Measure 2	**15,337**	**76,705**

Measure Costs

Table 15. Measure 2 Costs

Program Title	Charging Infrastructure Costs	Matching Funds
DC Fast	$9,198,685	$3,158,601
Level 2	$4,406,778	$989,270
TOTAL	**$13,605,463**	**$4,147,871**

Intersection with Other Funding Availability

All Phase 1 and Phase 2 ZEV applications funded through NCDEQ's VW Mitigation program were reimbursed with State allotted mitigation funds. NCDEQ is allocating the full 15% ($9,700,000) allowed in the VW State Trust Agreement for ZEV charging infrastructure projects as outlined in the NC Mitigation Plan. Awardees are able to contribute matching organizational funds to make projects cost effective in terms of VW funds spent, as well as to seek additional outside funding sources to help compensate for overall project costs.

Measure 3. Implement programs to increase efficiency and reduce GHG emissions at deep water and inland ports.

This measure aims to implement programs to improve energy efficiency associated with freight shipping across the State and lower GHG emissions along the State's critical freight corridors that serve deep water and inland ports. These programs include upgrading technology at freight terminals and ports, expanding more efficient freight corridors across the state, and coordinating with private industry to increase electrification of equipment.

The North Carolina State Ports Authority is an enterprise economic development agency for the State of North Carolina that was established by the North Carolina General Assembly in 1945 and is now considered an independent agency of the NCDOT.[52] NC Ports owns and

[52] *North Carolina State Ports Authority. (n.d.). History. NC Ports. https://ncports.com/about-the-ports/history/.*

maintains the Port of Wilmington, the Port of Morehead City, as well as the Charlotte Inland Port. NC Ports is governed by an eleven-member Board of Directors.

North Carolina Ports contributes to economic vitality at the regional and national level by providing North Carolina businesses unrestricted access to the global marketplace. A 2022 study by NCSU determined that NC Ports contributed approximately $16.1 billion annually to the state's economy.[53] The ports directly and indirectly support more than 88,200 jobs across North Carolina, which comprises a substantial portion of the state's economy. The Port of Wilmington plays an important role in the supply chain decisions of companies with operations in North Carolina and those considering locating manufacturing and distribution operations into the region.

Port of Wilmington

The Port of Wilmington is located on the Cape Fear River approximately two miles south of the Wilmington downtown area. It has nine berths with approximately 6,800 linear feet of wharf. The Port of Wilmington's operations encompass approximately 352 developed acres along the Cape Fear River and an additional 100 acres of undeveloped property adjacent to the terminal to the north and another 90 acres on Raleigh Street that is partially developed. Annual volumes in the Wilmington Harbor, NC (Waterway) average just under 7 million short tons; over 3 million of those move through the North Carolina State Ports Authority's Port of Wilmington.[54]

CSX Transportation, which owns and operates the largest intermodal rail network in the eastern United States, provides daily service for container, boxcar, tanker, and general cargo services via a short line known as the Wilmington Terminal Railroad (WTRY).[55] The Port of Wilmington is designated as a Foreign Trade Zone 214, along with Wilmington International Airport (ILM). Primary Highway Freight System (PHFS) routes, North Carolina Priority Highway Freight Network (NCPHFN) routes, Critical Rural Freight Corridors (CRFCs), Critical Urban Freight Corridors (CUFCs), and local truck routes are all found adjacent to the Port of Wilmington and are heavily utilized by freight traffic.[56]

The Port of Wilmington is also one of the 15 Strategic Seaports, as designated by the U.S. Department of Defense, and as such must maintain the capability and capacity to meet the

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[53] *Personal communication from Stephanie Ayers, NC Ports, July 2025.*

[54] *Program Evaluation Division, North Carolina General Assembly. (2019, October 21). Evaluation of efficiency and effectiveness of state ports at Wilmington and Morehead City (Report No. 2019-07). https://www.ncleg.gov/Files/ProgramEvaluation/PED/Reports/documents/Ports/Ports_Report.pdf.*

[55] *Barchart. (2025). CSX Corporation: Rail-based freight services across the U.S. and Canada. CSX. CSX rail, intermodal and rail-to-truck transload services - CSX.com*

[56] *Genesee & Wyoming Inc. (2024). Wilmington Terminal Railroad – A Genesee & Wyoming Company. https://www.gwrr.com/wtry/.*

national security needs of the nation.[57] The Port of Wilmington serves a variety of customers including container, military, specialized, oversized, rolling stock (ro-ro), and general cargo. The Port of Wilmington's cargo mix includes agriculture products, industrial products, building materials, paper and fiber, apparel and textiles, furniture and home goods, appliances, rubber, and fresh produce. North Carolina has a robust agriculture industry with strong exports such as sweet potatoes and frozen proteins.[58]

GHG Reduction projects at the Port of Wilmington

Measure 3-1 Intermodal Yard Improvements and Shipping Facility

The purpose of the Port of Wilmington Rail Yard Improvements Project is to support the operation of the Queen City Express (QCE), an intermodal container train service operating between the Port of Wilmington and Charlotte where the Port maintains an inland port. Services are being expanded to include connections with the Carolina Connector (CCX) regional rail container hub located in Rocky Mount, NC and the rest of the CSX Transportation rail system. The new facility will be able to handle 50,000 intermodal rail moves annually, up from 14,000, and is expected to divert 250,000 container boxes from trucks to rail over the next decade.[59]

Measure 3-2 North Carolina Port Container Handler and Drayage Replacement

The project will replace cargo handling equipment with newer, more efficient equipment; the expected outputs and outcomes include reduction of carbon emissions at the Port of Wilmington. The target fleet type is container handling equipment and terminal drayage trucks. The project proposed to replace two container handlers that are CARB/low NOx certified, one Class 8 non-DOT certified yard tractor, and three Class 8 DOT Certified with VIN dray terminal trucks in Wilmington.[60]

Measure 3-3 Pedestrian Safety Rail Bridge with Secured Access

The Pedestrian Safety Rail Bridge with Secured Access project will construct the facilities needed for offsite port terminal access for more than 250 employees and port users, reducing GHG emissions from approximately 120 cars and trucks daily. The improvements include an off-terminal parking facility to meet the parking needs of employees and visitors. This move will effectively relocate a significant portion of vehicles currently parked within the port

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[57] *North Carolina State Ports Authority. (2025). Home – NC Ports. https://ncports.com/.*

[58] *Stradling, R. (2022, January 9). Shipping containers are only part of the cargo traffic moving in and out of NC ports. News & Observer. https://www.newsobserver.com/news/business/article256993927.html.*

[59] *North Carolina State Ports Authority. (2022). Port of Wilmington – Intermodal yard improvement project: Benefit-cost analysis report. https://connect.ncdot.gov/resources/PORTS2022/Documents/NCPorts_RAISE22_Intermodal_BCANarrative.pdf.*

[60] *U.S. Environmental Protection Agency. (2025, April 22). Drayage truck replacements improve air quality in the Mid-Atlantic. Ports Initiative. https://www.epa.gov/ports-initiative/drayage-truck-replacements-improve-air-quality-mid-atlantic.*

terminal. By removing this traffic from the core port area, the port anticipates a substantial reduction in congestion, leading to improved traffic flow, decreased vehicle idling time, and ultimately, faster and more efficient cargo movement, therefore reducing GHG emissions. The project will increase mobility through this growing economic hub with a dual benefit of on-terminal freight efficiency and increased cargo space and increased employee and port user safety through the reduction of personal vehicles within the terminal.[61]

Future planned project - Future Refrigerated (Reefer Container) Yard Phase 3 (576 plugs)

The Port of Wilmington in North Carolina has a refrigerated (reefer) container yard that handles refrigerated cargo. This yard is strategically located near the Port of Wilmington Cold Storage and has been expanded to accommodate more reefer containers. The expansion includes new reefer racks and service areas, boosting the port's ability to handle perishable goods. This project will be included in future monitoring and reporting as it comes online. GHG emissions will be reduced given the switch from diesel generators to electric generation.[62]

Port of Morehead City

The Port of Morehead City is one of two deep water ports owned by the Authority, integral to the global supply chain needs of the region's businesses, offering bulk, breakbulk, specialty cargo, and warehousing services that connect the state with the global economy. Located 4 miles off the Atlantic Ocean, within 700 miles of more than 70% of the U.S. industrial base, and with over 1 million square feet of covered storage, the Port of Morehead City is well poised to address current and future cargo needs.[63] Rail service, including on-dock rail, is provided by Norfolk Southern and a short-line railroad, Carolina Coastal Railway. In FY23, the Port of Morehead City facilitated the movement of nearly 1.4 million short tons of bulk and breakbulk cargo, reflecting 12% year-on-year growth. This growth was driven in large part by agricultural commodities, such as fertilizer, grain, feed, and forest products.

The Port of Morehead City operates under Foreign Trade Zone 214, attracting businesses involved in international trade such as Nutrien. The Port of Wilmington is aStrategic Seaport, as designated by the U.S. Department of Defense, and as such, must maintain the capability and capacity to meet the national security needs of the nation. The Port must have a readiness plan for how the Port will be used during a contingency, training of personnel, and security. Improved infrastructure will promote the retention of the Strategic Seaport designation and ensure the Port's capabilities to respond to national emergencies and provide transportation and material readiness. The Port of Morehead City is also the port of embarkation and

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[61] *Wilmington Urban Area Metropolitan Planning Organization. (n.d.). Plans.* Plans - Wilmington Urban Area Metropolitan Planning Organization.

[62] *North Carolina State Ports Authority. (2020, April 16). North Carolina Ports opens new refrigerated container yard. NC Ports.* https://ncports.com/about-the-ports/news/north-carolina-ports-opens-new-refrigerated-container-yard/.

[63] *North Carolina State Ports Authority. (n.d.). Port of Morehead City. NC Ports.* https://ncports.com/port-facilities/port-of-morehead-city/.

debarkation for U.S. Marine Corps at Camp Lejeune and Cherry Point. Visiting Navy ships also use the Port's deep-water berths and the state-owned ramps at the terminal for loading amphibious ships. Vessels operated by or chartered to the Military Sealift Command berth at the Aviation Fuel Terminal on Radio Island.[64]

The Port of Morehead City terminal is accessible via water, rail, and truck. Interstates 95 and 40 are easily accessed via US Highways 70 and 17.[65] The Atlantic Intracoastal Waterway connecting Aurora to Morehead City is part of designated M-95, a marine alternative to I-95 as part of America's Marine Highway Program, an initiative to move more cargo on the water rather than on crowded highways.[66]

The strategic advantage of the Port is further amplified by its proximity to the Coastal Carolina Regional Airport (EWN), a full-service commercial airport spanning over 785 acres.[67] This positioning and access to a multimodal transportation network makes the Port an attractive choice for suppliers seeking efficient transportation to and from major industrial centers.

GHG Reduction project at the Port of Morehead City

Measure 3-4 Modernization & Revitalization of Barge Berths Port of Morehead City

The Modernization and Revitalization of Barge Berths project will rebuild the barge berths at the Port of Morehead City in the area of the port used by Nutrien, the world's largest provider of potash (used as an agricultural fertilizer). This investment will extend the life of the barge berths for 50 years and allow Nutrien to continue serving its global customers. Implementation timelines are presented in Table 15 below. Without this investment, cargo that currently moves by barge would instead need to be transported by truck and/or rail. Shifting this freight to barges avoids over 280 truck trips per week, or a combination of more than 250 truck trips and one rail trip per week when moved by both modes. [68]

Implementation Timelines and Milestones

Table 16. GHG Reduction Projects Timeline

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[64] *North Carolina Department of Transportation. (2024). Project description: Modernization and revitalization of barge berths at the Port of Morehead City [PDF]. https://connect.ncdot.gov/resources/PORTS2024/Documents/Project%20Description_FINAL%20RAISE%20F24.pdf*

[65] *North Carolina State Ports Authority. (n.d.). Port of Morehead City. NC Ports. https://ncports.com/port-facilities/port-of-morehead-city/*

[66] *U.S. Department of Transportation Maritime Administration. (2023). M-95 Marine Highway Route Description [PDF]. https://www.maritime.dot.gov/sites/marad.dot.gov/files/2023-01/M-95%20Marine%20Highway%20Route%20Description.pdf*

[67] *Coastal Carolina Regional Airport. (n.d.). Ground transportation. https://www.flyewn.com/terminal/transportation/*

[68] *North Carolina State Ports Authority. (2024, May 10). Modernization and revitalization of barge berths – Port of Morehead City: 2024 Port Infrastructure Development narrative. North Carolina Department of Transportation. https://connect.ncdot.gov/resources/PORTS2024/Documents/NarrativeP24.pdf.*

Measure No.	Title	Timeline	Milestones
3-1	Intermodal Yard Improvements and Shipping Facility	2022-2044	Incremental increases in rail container capacity are anticipated to grow by 1% per year until 2044
3-2	NC Port Container Handler and Drayage Replacement	2024-2026	2024 – Grant award and administration, Project bidding
			2025 – Procurement
			2026 – Installation, Commissioning of equipment, Scrappage
			Ongoing – Reporting, Community engagement, Workforce development
3-3	Pedestrian Safety Rail Bridge	2025-2027	2025 – Design
			2025 Q4-2026Q2 – NEPA
			2026 Q2-3 – Permits / Approvals
			2026 Q3 – 2027 – Construction and Community Engagement
3-4	Modernization & Revitalization of Barge Berths[6]	2024-2027	2024 Q4-2025 Q2 – Environmental Review & Final Design; Permit Approval
			2025 Q2 & Q3 – Procurement
			2025 Q4 – 2027 – Construction
			Ongoing – Community Engagement

Metrics for Tracking Progress

To track progress on this measure, NCDEQ will gather information from the grant applications or spreadsheets to each sub-measure listed below.

3-1. Intermodal Yard Improvements and Shipping Facility | The main metric for tracking progress for this sub-measure is the diversion of truck freight to rail containers. The total freight diverted from trucks to rail is expected to increase from 6,000 rail containers in 2020 to 50,016 in 2044.[69] There are several additional metrics that

[69] *Port of Wilmington - Intermodal Yard Improvement Project. Table 1. Current and Projected Traffic.*

include decreases in heavy-duty truck traffic, which results in reduced accidents, road wear, fuel use, congestion and truck emissions.

3-2. NC Port Container Handler and Drayage Replacement | The metrics for tracking progress in this sub-measure are changes in fuel consumption by the replacement and scrappage of equipment specified thusly also improving air quality for the surrounding communities.

3-3. Pedestrian Safety Rail Bridge | The metrics for tracking progress in this sub-measure are reduced VMT, increased use of shuttles, and decreased accidents.

3-4. Modernization & Revitalization of Barge Berths | The main metric for tracking progress is the increased use of barges to move cargo rather than truck or rail.

Quantified GHG Emission Reductions

GHG emission reductions were estimated for each sub-measure and then totaled for Measure 3, as shown in Table 16. The emission estimates were derived using several methodologies that are further described in Appendix E.

Table 17. Measure 3 Quantified GHG Emission Reductions (MT CO2e)

Measure No.	Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
3-1[70]	Intermodal Yard Improvements and Shipping Facility[a]	4,700	11,330
3-2[71]	NC Port Container Handler and Drayage Replacement[b]	759	759
3-3[72]	Pedestrian Safety Rail Bridge[c]	2,589	2,589
3-4[73]	Modernization & Revitalization of Barge Berths[d]	3,400	3,400[e]
	Total	11,448	18,078

[a] total emissions reduced include decreased emissions from trucks minus increased emissions from rail; estimates for 2050 as assumed to be the same as those estimated for 2044 because the total rail car capacity of the rail like will be at a maximum unless or until a gantry crane is deployed.
[b] total emissions reduced for lifetime of project are estimated to be 2509 short tons CO2. This project will conclude in 2026; therefore, it is assumed that the emission reductions will be held constant.
[c] total emissions reduced is assumed constant over time because the project will be complete in 2027 and the number of vehicles in the offsite parking location will remain constant given the spaces allocated.
[d] emissions calculated for this sub-measure are for cargo moved by truck in lieu of barge
[e] total emissions reduced is assumed constant over time because the project will be completed before 2050.

Measure Costs

Each sub-measure estimated costs for implementation differently, therefore all sub-measure estimations are summarized below. For more information see Appendix E.

3-1. Intermodal Yard Improvements and Shipping Facility | A quantitative benefit-cost analysis (BCA) was performed using available information about current truck drayage practices and current and proposed train operations, USDOT guidance, and supported by documentable costs and industry research data. The BCA presented likely underestimates benefits. Changes in the workforce that would help drive economic growth were not incorporated into this modeling. Future years' costs and benefits were

[70] 1.2_NCPorts_RAISE22_Intermodal_BCA_V3.xlsx
[71] *https://ncconnect.sharepoint.com/:w:/r/sites/Cprg/_layouts/15/Doc.aspx?sourcedoc=%7B3BC54C1A-B0EA-4C0A-988E-0CFCBD67004D%7D&file=2_NC%20Port%20Emissions%20Calculations_7152024.docx&action=default&mobileredirect=true*
[72] *https://ncconnect.sharepoint.com/:x:/r/sites/Cprg/_layouts/15/Doc.aspx?sourcedoc=%7BBEB2E6E0-9C08-430A-810B-37E2AD974512%7D&file=3_BCACalculationsR25%20-%20Copy.xlsx&action=default&mobileredirect=true&wdOrigin=OUTLOOK-METAOS.FILEBROWSER.FILES-SITES-FOLDER*
[73] *https://ncconnect.sharepoint.com/:x:/r/sites/Cprg/_layouts/15/Doc.aspx?sourcedoc=%7BA3D5A23D-0881-457C-BD3E-3F7C33DA854E%7D&file=4_BCA%20Calculations%20Barge%20Berths%20P24.xlsx&action=default&mobileredirect=true&wdOrigin=OUTLOOK-METAOS.FILEBROWSER.FILES-SITES-FOLDER*

projected, in constant dollars, for a period extending 20 years beyond construction which is approximately 2044.

The total capital cost is $18.1 million dollars, and the total quantified benefits is $86.5 million dollars, which includes reduced accidents, non-carbon emission reductions, fuel cost savings, road wear savings, reduced highway congestion, consumer transport cost reduction and increased inventory holding costs.

3-2. Container Handler and Drayage Replacement | The primary costs for this sub-measure are for the purchase of 3 class 8 dray trucks and scrap disposal; purchase of one class 8 dray truck not DOT certified and scrap disposal; purchase of 2 container handlers and scrap disposal. The NC Port Authority is prepared to provide long-term operations and maintenance costs for these vehicles for their lifetime; however, those costs were not included in the documentation.

3-3. Pedestrian Safety Rail Bridge | The pedestrian rail bridge will safely transport personnel across six active rail tracks, eliminating the risk of pedestrian-rail incidents. Estimated GHG reductions come from a reduction in approximately 80 daily VMT. The primary costs for this sub-measure are for the construction of the pedestrian bridge; however, additional capital costs of $17.7 million dollars include a dedicated shuttle service, pervious parking surfaces, solar panels to power the shuttle system and lighting. The lifetime analysis corresponds to a 20-year benefit period until 2049.

3-4. Modernization & Revitalization of Barge Berths | The BCA for this project included three scenarios all focused on the costs of not building or repairing the barge berths. Two scenarios include transferring cargo to trucks, or trucks and rail. The BCA for costs avoided for (1) diversion of dry cargo to both truck and rail estimated at $61.3 million dollars or (2) diversion of dry cargo to truck only estimated at $49.5 million dollars. These costs would be realized if the barge berths are not constructed. They are presented below in Table 17.

Intersection with Other Funding Availability

Table 18. Other Funding Availability – Port of Morehead City

Measure No.	Title	Funding Source	Estimated Project Cost ($)	Funding Match ($)	NC Ports Match ($)	Nutrien Match ($)
3-1	Intermodal Yard Improvements and Shipping Facility	RAISE	22,567,500	18,054,000	4,513,500	
		CMAQ	2,475,528	1,980,422	495,106	
3-2	Container Handler and Drayage Replacement	DERA	2,370,000	708,750	1,661,250	
3-3	Pedestrian Safety Rail Bridge	RAISE/ BUILD	12,402,182	9,921,746	2,480,436	
3-4	Modernization & Revitalization of Barge Berths	PIDG	18,887,540	14,921,158	1,983,191	1,983,191
COSTS			58,702,750	45,586,076	11,133,483	1,983,191
TOTAL COST						**117,405,500**

Measure 4. Supporting Regional Strategies to Reduce Vehicle Miles Traveled (VMT) (Unfunded) [74]

As of 2020, North Carolina's transportation sector accounted for approximately 36% of statewide GHG emissions, or 50.35 $MMTCO_2e$, according to the state's most recent Inventory. Approximately 75% of these emissions were attributable to light-duty vehicles. Between 2003 and 2019, VMT in North Carolina increased by 31%, compared to 13% nationally, underscoring the challenge of managing on-road emissions growth.

Under a BAU scenario, transportation emissions in North Carolina are projected to rise to 52.01 $MMTCO_2e$ by 2030, before falling to 35.56 $MMTCO_2e$ by 2050 due to anticipated EV adoption, cleaner fuel standards, and vehicle emission regulations. However, further emissions reductions could be achieved through complementary strategies that reduce VMT, particularly among light-duty vehicles.

In the North Carolina PCAP, Measure 5 proposed leveraging innovative planning, infrastructure investments, and land use strategies to reduce VMT. These included increased support for multimodal transportation, pedestrian- and bike-friendly infrastructure, and community design approaches that reduce reliance on single-occupancy vehicles. Modeling for the PCAP

[74] *NC Primary Climate Action Plan. https://www.deq.nc.gov/north-carolina-priority-climate-action-plan-climate-pollution-reduction-grant/open*

estimated potential GHG reductions of 0.004 $MMTCO_2e$ in 2030 and 0.02 $MMTCO_2e$ in 2050 from these strategies, relative to BAU projections.

North Carolina's CPRG Implementation Workplan included a request for $11.8 million to support select community-based VMT-reduction projects. These estimates reflected the cost of capital investments (e.g., bike and pedestrian infrastructure). This funding request was not approved, and no implementation activities are currently underway. This measure is therefore included in the CCAP to document prior planning efforts, highlight regional collaboration, and identify future opportunities should funding and authority align.

Implementation Authority and Responsibilities

NCDEQ does not have regulatory or funding authority to implement VMT reduction strategies directly. Primary jurisdiction lies with the NCDOT and local and regional planning organizations. However, implementation of stand-alone pedestrian and bicycle infrastructure is limited at the state level due to the Strategic Transportation Investments (STI) law, which restricts funding for non-motorized projects that are not bundled with larger roadway improvements.

As a result, VMT-reduction strategies are primarily implemented at the regional and local level. For example, the Centralina Regional Council incorporated VMT reduction goals in their PCAP, including plans to expand greenway networks, promote bike and pedestrian mobility, and reduce reliance on single-occupancy vehicles. This state CCAP includes Measure 5 to recognize and elevate regional planning leadership and to document strategies previously identified through the PCAP and the Implementation Workplan. Including the PCAP Measure 5 in the CCAP also signals the state's interest in supporting regional strategies with technical assistance and cross-agency coordination should future resources become available.

Implementation Timelines and Milestones

This measure is designed to support regional efforts rather than establish a statewide mandate. As such, implementation will depend on regional initiative readiness, availability of funding through complementary programs, and coordination with local governments, and planning organizations. The state is not leading this measure's implementation and does not currently anticipate allocating state-level funding or staff resources to advance the measure directly.

Implementation timelines and milestones will be determined by the initiating regional partner(s) and are expected to align with their transportation planning processes.

Where applicable, the state may offer technical guidance or support data-sharing to help regional entities track emissions impacts and report progress under voluntary frameworks. However, the pace and scope of implementation will be determined by the regional entities leading the effort.

Metrics for Tracking Progress

This measure is being led by a regional partner and is included in the CCAP to reflect regionally driven strategies to reduce transportation-related emissions. The state is not responsible for

implementing this measure and does not intend to establish or track performance metrics unless data is voluntarily shared by the regional entity.

Where data is made available, the state may use it to support high-level analysis of emissions trends or to inform future planning. Potential indicators—defined and managed by the regional lead—may include:

- Changes in vehicle miles traveled (VMT)
- Mode shift indicators (e.g., increased transit or active transportation use)
- Adoption of VMT-related goals or policies
- Implementation of supporting infrastructure or land-use strategies
- Regionally estimated GHG reductions

Any emissions accounting in the state's reporting will rely on regionally supplied data and methodologies. The state will not independently quantify reductions for this measure without direct input from the implementing region. Where appropriate, the state may offer technical assistance or support alignment of regional metrics with EPA-recognized frameworks, but it will not impose requirements or assign targets related to this measure.

Quantified GHG Emission Reduction

Regionally supported VMT-reduction strategies were estimated to result in cumulative reductions of 0.02 million metric tons of CO_2-equivalent ($MMTCO_2e$) statewide by 2050. This estimate was based on modeled assumptions using available data from regional and national sources and is intended to represent indicative potential, not a specific policy commitment.

For the purposes of the CCAP:

- This estimate is acknowledged but not duplicated in the state's GHG accounting;
- The state does not claim credit for these reductions in implementation tracking; and
- Any emissions benefits from regionally led efforts will be counted once, either in the regional CCAP or as supplemental information in statewide analyses.

Future updates to the CCAP may revise this estimate if new data becomes available from implementing regions or if additional modeling is conducted at the regional or state level.

Measure Costs

This measure was included in North Carolina's CPRG Implementation Workplan, which proposed an estimated $11.8 million to support community-scale VMT reduction strategies in

select areas across the state.[75] This estimate reflected the capital costs of constructing pedestrian- and bicycle-friendly infrastructure, such as greenways and protected bike lanes. It did not include costs associated with planning, staffing, project management, or ongoing maintenance.

Because the state does not have regulatory authority over transportation planning and no CPRG funding was awarded for this measure, the costs presented here are illustrative only and based on project concepts developed during the planning phase. Actual costs to implement similar projects at the local or regional level would vary significantly depending on location, project scope, and local funding match requirements.

While the State of North Carolina is not positioned to implement or fund these projects directly, this measure reflects the state's support for future opportunities to enable VMT reduction through collaborative planning, technical assistance, and expanded access to funding sources.

Intersection with Other Funding Availability

Although this measure was not funded through the Implementation Workplan, there are several existing or emerging funding sources that could support implementation of VMT-reduction strategies at the regional or local level. These include federal and state transportation and planning programs, as well as regional funding mechanisms that prioritize multimodal infrastructure and equitable access.

Potential Funding Sources Include:

1. Federal Surface Transportation Block Grant Program (STBG):
   Administered by the Federal Highway Administration (FHWA), this flexible funding source can support pedestrian and bicycle infrastructure when included in broader transportation projects.[76]
2. Carbon Reduction Program (CRP):
   A federal program under the Bipartisan Infrastructure Law (BIL) that provides funds to reduce transportation emissions, including through VMT reduction, mode shift, and nonmotorized infrastructure.[77]

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[75] *NC Implementation Grant Application. April 2024. https://www.deq.nc.gov/energy-climate/state-energy-office/inflation-reduction-act/climate-pollution-reduction-grant#April2024DEQsubmittedtheimplementationworkplantotheEPA-17648*

[76] *Federal Highway Administration. (n.d.). Surface Transportation Block Grant Program (STBG). U.S. Department of Transportation. Retrieved from https://www.fhwa.dot.gov/specialfunding/stp/*

[77] *Federal Highway Administration. (n.d.). Carbon Reduction Program (CRP) Fact Sheet. U.S. Department of Transportation. https://highways.dot.gov/media/57901*

3. Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grants:
   This U.S. DOT program funds projects that have significant local or regional impact, including those that improve safety, accessibility, and mobility in underserved areas.[78]
4. Congestion Mitigation and Air Quality (CMAQ) Program:
   Available in certain urbanized areas, this federal program supports projects that reduce transportation-related emissions.[79]
5. Metropolitan Planning Organization (MPO) and Rural Planning Organization (RPO) Allocations:
   Local and regional transportation planning bodies may have funding flexibility to advance VMT-reduction priorities that align with their long-range plans.[80]
6. Local Capital Investment Programs:
   City and county governments may finance bike, pedestrian, and complete streets projects through general obligation bonds, sales tax measures, or capital improvement funds.

At the time of this plan's submission, no specific project proposals tied to Measure 4 have secured alternative funding. However, NCDEQ and regional partners remain interested in identifying and supporting future opportunities to align GHG reduction goals with transportation planning, particularly where VMT reductions yield community co-benefits.

[78] *U.S. Department of Transportation. (2024). Rebuilding American Infrastructure with Sustainability and Equity (RAISE) Grant Program Fact Sheet. https://localinfrastructure.org/wp-content/uploads/2024/06/Rebuilding-American-Infrastructure-with-Sustainability-and-Equity-RAISE-Grant-Program-Fact-Sheet-2024.pdf*

[79] *Federal Highway Administration. (n.d.). Congestion Mitigation and Air Quality Improvement (CMAQ) Program. U.S. Department of Transportation. https://www.fhwa.dot.gov/infrastructure-investment-and-jobs-act/cmaq.cfm*

[80] *North Carolina Department of Transportation. (n.d.). Metropolitan Planning Organizations (MPO). https://connect.ncdot.gov/projects/planning/TPB%20Documents/Metropolitan%20Planning%20Organizations%20(MPO).pdf*

4.3.3 Sector 2 Electricity Generation Measures 5 and 6

As other sectors seek to electrify to reduce emissions, being able to source electricity from distributed and renewable resources is what drives those reductions. Table 18 demonstrates total reductions associated with electricity sector measures. Increasing the amount of electricity generated from renewable resources like solar, wind and geothermal will likely help offset generation from electric generating units. North Carolina's electricity generation and use sector accounted for approximately 30% of statewide GHG emissions, or 41.77 $MMTCO_2e$, according to the state's most recent Inventory.

Electricity Key Take Aways

NCDEQ has developed and modeled two electricity measures that collectively will reduce GHG emissions by 1.3% by 2030 and 6.2% by 2050. These measures include:

Increase the amount of electricity generated by distributed and renewable resources in North Carolina through promotion and adoption of solar, geothermal and onshore wind resulting in GHG reductions of 345,498 $MTCO_2e$ by 2030 and 458,691 $MTCO_2e$ by 2050 at an approximate cost of $384 million.

Improve energy resiliency in North Carolina communities by implementing temporary microgrid solutions designed to bring power, water purification, and communications. These actions result in 13,157$MTCO_2e$ by 2030 and 65,784 $MTCO_2e$ by 2050 at an approximate cost of $5.8 million.

Table 19. Total GHG reductions in $MTCO_2e$ that can be implemented through Measures 5 and 6.

Measure Number-Title	Short-Term Implementation Scenario Year 2030 Emissions ($MTCO_2e$)	Long-Term Implementation Scenario Year 2050 Emissions ($MTCO_2e$)
5 – Distributed and Renewable Resources	345,498	458,691
6 - Microgrids	13,157	65,784
Total	**358,655**	**524,475**

Implementation Authority

See Figure 8 Implementation Authority and Lead Agencies.

Measure 5. Increase the amount of electricity generated by distributed and renewable resources in North Carolina.

Utility scale power generation over the last 15 years has shifted away from coal and toward natural gas, accompanied by a dramatic rise in large-scale utility solar energy generation, which now supplies more than 9% of the state's power generation. However, North Carolina lags behind other states when it comes to residential and small-scale distributed solar, ranking just 17th in residential net-metered solar capacity.[81]

Looking to accelerate the shift towards cleaner electricity generating resources, Executive Order 246 and S.L. 2021-165, Energy Solutions for North Carolina, set a goal for a 70% reduction in carbon emissions by 2030 and carbon neutrality by the year 2050 for the electric power sector. [82,83] The North Carolina Utilities Commission is developing a carbon plan to achieve these reductions.

For this measure, North Carolina's CPRG work will focus on programs and incentives that increase electricity generation from distributed and renewable resources, focused on but not

[81] *North Carolina Utilities Commission. (n.d.). About the NC Utilities Commission. Retrieved from https://www.ncuc.gov/Aboutncuc.html*

[82] *North Carolina General Assembly. (2021). House Bill 951 / SL 2021-165: Energy Solutions for North Carolina. Retrieved from https://www.ncleg.gov/BillLookUp/2021/H951*

[83] *North Carolina Department of Transportation. (n.d.). Rural Planning Organizations (RPO). Retrieved from https://connect.ncdot.gov/projects/planning/TPB%20Documents/Rural%20Planning%20Organizations%20(RPO).pdf*

limited to residential, commercial, government, institutional, and other small scale solar energy, with an emphasis on low- and moderate-income residents. Programs identified for this measure will also include geothermal and wind projects that are realizing, or will realize, GHG emission reductions in this sector.

Measure 5-1. EnergizeNC

On June 28, 2023, EPA released the $7 billion Solar for All Notice of Funding Opportunity, part of the $27 billion Greenhouse Gas Reduction Fund which was authorized by congress in the Inflation Reduction Act.[84] On April 22, 2024, EnergizeNC, North Carolina's Solar for All (SFA) coalition, was selected by the EPA for $156 million in funding through the Greenhouse Gas Reduction Fund (GGRF). As of August 2025, the NCDEQ has received and is reviewing a letter from EPA on the potential termination of the Solar for All program. The results of these federal actions for the EnergizeNC program are uncertain; therefore, what is included in the CCAP continues to highlight the projected benefits of the program for the residents of NC.

The EnergizeNC program aims to transform solar energy in the state by expanding access to residential solar energy for low- and moderate-income families, through incentives targeting single-family homes, affordable multi-family housing, and community solar projects, and by strengthening solar job training and the solar job market. Through these efforts, the EnergizeNC program will support the achievement of the ambitious carbon reduction goals already set at the state level while ensuring low- and moderate-income families directly benefit. Specifically, by enabling the rapid deployment of distributed solar generation and associated storage, EnergizeNC aims to extend the clean energy benefits of solar energy to over 12,500 low-income households in communities across the state. This will result in at least 43.4 megawatts (MW) of new residential solar energy capacity and 0.081 megawatt-hours (MWh) of residential energy storage by the end of the five-year program, which will reduce greenhouse gas (GHG) emissions and lower energy costs. These solar installations are projected to reduce GHG emissions by 458,691 $MTCO_2e$ over a twenty-year period.[85]

Implementation Timelines and Milestones

While the program was initially awarded in April 2024, the activities fully commenced in December 2024 with the finalization of an amended award agreement. This marked the

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[84] *U.S. Environmental Protection Agency. (2024, April 22). Biden-Harris Administration announces $7 billion Solar for All grants to deliver residential solar. Retrieved from https://www.epa.gov/newsreleases/biden-harris-administration-announces-7-billion-solar-all-grants-deliver-residential*

[85] *North Carolina Department of Environmental Quality. (n.d.). Solar for All. Retrieved from https://www.deq.nc.gov/energy-climate/state-energy-office/inflation-reduction-act/solar-all*

beginning of EnergizeNC's planning year, during which the project team will develop an implementation plan and finalize the design of the program's financial assistance products. This process will include community and stakeholder engagement opportunities. According to the terms and conditions of the grant, the program must conclude by April 2029. Figure 12 shows the overarching timeline.

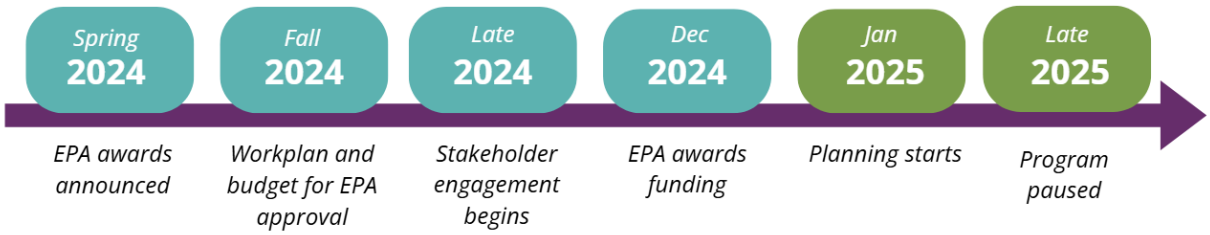

Figure 12. EnergizeNC Timeline and Milestones

Metrics for Tracking Progress

The metrics for tracking progress include, where practicable:

• New generation capacity is broken down by residential solar and residential-serving community solar (MW), specifically manufacturers documents or permitting / utility interconnection forms can be used to identify expected nameplate capacity, whether a battery storage system is also installed referencing real-world numbers when feasible.

• Estimated GHG emissions reduced and avoided (CO_2 and CO_2e if available)

• Estimated savings per household ($/household)

• Number of jobs created, and other outcomes related to workforce development, based on contractor feedback.

Measure Costs

To support the implementation of EnergizeNC, contracts will be established with vendors to provide technical assistance, workforce development, community engagement, reporting and evaluation, contractor oversight, financial incentives, and other related services as determined by the State Energy Office (SEO). These contracts will supplement the capacity of SEO and Coalition staff as needed over the five-year duration of the program (Years 1–5). Implementation of this program will result in costs related to this measure. EnergizeNC has

received $156 million in funding to support program activities over this five-year period.[86] At this time, there is no intersection with additional funding sources; however, given the program's alignment with the NC Clean Energy Fund,[87] there is potential for future funding opportunities that could offset project costs for homeowners.

Measure 5-2. Geothermal Project

Wake Technical Community College selected the Wake East Campus as the site to provide a new generation of sustainable and innovative energy source in Wake County North Carolina. The community college elected to build a thermal energy hub for the campus buildings on the eastern campus utilizing a ground source heat pump, which is referred to as a hybrid geothermal system. The hybrid geothermal system utilizes the earth's constant temperature to assist in heating and cooling a building. The system consists of a heat pump that is connected to a traditional Heating, Ventilation, and Air Conditioning (HVAC) system. The HVAC system works in conjunction with the geothermal heat pump to supplement additional heating and cooling when needed.[88]

The design features 297 wells dug to a depth of 500 feet and 297,000 feet of vertical piping. This hybrid geothermal design is predicted to use one-third less energy and emit 50% less carbon emissions than a traditional facility-wide heating and cooling system. Furthermore, the roof of the energy plant features 283 high-efficiency solar panels, which have the capacity to produce up to 160,956 kWh per year of energy. The 15,700 square-foot plant was designed and constructed by HH Architecture and Skanska USA Building and was funded through a $54 million bond.

The plant is anticipated to save the campus approximately $18,000 a year in energy costs and has currently achieved a Four Green Globes[89] rating, which is the first facility in North Carolina to receive this status. The plant has also received awards from the City of Raleigh Climate Action Award in 2023, the DBIA Southeast Region Project of the Year, and the Green Building

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[86] *Office of Governor Roy Cooper. (2024, April 22). Governor Cooper announces $156 million EPA award to strengthen solar energy use in communities across North Carolina. https://governor.nc.gov/news/press-releases/2024/04/22/governor-cooper-announces-156-million-epa-award-strengthen-solar-energy-use-communities-across-north-0*

[87] *NC Clean Energy Fund. https://coalitionforgreencapital.com/north-carolina-clean-energy-fund/*

[88] *Skanska USA. (2024, April 26). Skanska completes geothermal central energy plant at Wake Tech Community College. Retrieved from https://www.usa.skanska.com/who-we-are/media/press-releases/280522/Skanska-completes-geothermal-central-energy-plant-at-Wake-Tech-Community-College-*

[89] *U.S. Green Building Initiative (GBI). Green Globes Certification. Accessed September 5, 2025. https://thegbi.org/assessment-certification/green-globes-certification/*

Initiative's 2023 Project of the Year. [90,91,92] The central energy plant will also be used for students taking courses in green technology by allowing them to gain hands-on experience. Wake Tech intends to use the site as a Renewable Energy Training Center that supports training through WakeWorks® Apprenticeship.[93]

Implementation Timeline and Milestones

Construction for this project was completed in April 2024, timeline shown in Figure 13. Energy usage data collection started immediately and is reported monthly.

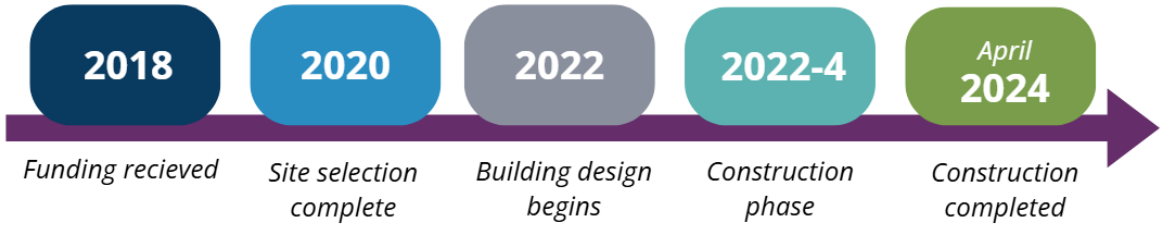

Figure 13. Geothermal Project Timeline

Metrics for Tracking Progress

Energy usage data is collected and reported annually to the NCDEQ-SEO as part of the Utility Savings Initiative (USI), which is discussed in Section 4.3.4.

Measure Costs

The hybrid geothermal system required an investment of $10,311,018 compared to $7,159,637 for a traditional chiller and gas-fired boiler system (see Table 19). The additional costs for the hybrid geothermal system are paid back in 25 years and a total savings of $139,634 are expected. Meaning the central energy plant is anticipated to provide a 35% lifetime savings as compared to a traditional chiller and boiler system.

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[90] *City of Raleigh. (2023). 2023 Environmental Award. Retrieved from https://raleighnc.gov/climate-action-and-sustainability/services/environmental-awards-program/2023-environmental-award*

[91] *Wake Technical Community College. (2024, November 26). College facility receives national recognition. Retrieved from https://www.waketech.edu/post/wt-news-story/352531*

[92] *Green Building Initiative. (2024, April 25). Wake Tech Community College's Central Energy Plant named GBI's 2023 Green Globes Project of the Year. Retrieved from https://thegbi.org/press/wake-tech-community-colleges-central-energy-plant-named-gbis-2023-green-globes-project-of-the-year/*

[93] *Salas O'Brien. (2024, May 7). An inside look at Wake Tech East's future-forward campus. Retrieved from https://salasobrien.com/news/wake-tech-east-future-forward-campus/*

Table 20. Traditional Chiller/Gas-Fired Boiler versus Hybrid Geothermal System Costs

	Traditional Chiller and Gas-Fired Boiler System	Hybrid Geothermal System
Electric Utility Costs	$1,899,713	$2,498,636
Gas Utility Costs	$1,289,871	$0
Water and Chemical Treatment	$1,125,106	$332,986
Total Operating Costs	$4,314,690	$2,831,622
Maintenance Costs	$341,888	$236,307
Investment Costs	$7,159,637	$10,311,018
Replacement Costs	$2,530,879	$377,086
Residual Value	$1,593,725	$1,142,299
Net Investment Costs	$8,096,971	$9,545,805
Total 25-year Costs	**$12,753,369**	**$12,613,734**
25-year Savings	***$0***	***$139,634***

Intersection with Other Funding Availability

The central energy plant has not received any state or federal funding. However, Wake Technical Community College's East Campus applied for utility-based energy efficiency incentives and solar photovoltaic (PV) rebate; the central energy plant project was credited with $145,340 and $75,000 respectively, through these Duke Energy programs. The college also applied for a $3.59 million federal tax credit under the IRA Elective Pay Clean Energy program. Of this credit, $3,256,780 is to be applied towards the central energy plant for geothermal & solar PV systems, if received. Wake Tech is awaiting notice if the federal tax credit will be granted. These incentives and credits will significantly reduce the initial payback of this project to less than 5 years.

Measure 5-3. Onshore Wind Project

The Timbermill Wind, LLC [94] project, located in Chowan County, is the second onshore utility-scale wind energy generating facility in North Carolina. Timbermill Wind was designed and constructed by Apex Clean Energy. Chowan County was selected for this project due to its verified wind resource, existing onsite transmission lines, expansive rural timber and agricultural lands, existing road infrastructure, and lack of sensitive military and environmental areas. The facility includes 45 modern wind turbines across 6,000 acres. The turbine field is estimated to produce 189 MW of energy annually, which could power 47,000 homes while displacing approximately 236,000 metric tons of carbon annually. [95]

Timbermill Wind has provided a host of benefits to the local economy since its construction. The project created over 200 construction jobs and hired local contractors to help build the facility. Over $25 million was spent with North Carolina businesses during the facility's construction. Chowan County has historically underperformed in employment growth compared to the rest of the state. During the facility's anticipated 30-year lifespan, it is anticipated to provide $1.1 million in associated labor income and $1.5 million in economic output per year. Timbermill Wind is also projected to generate up to $33 million in tax revenue over the facility's lifetime. The project will also support Google's commitment to powering its operations (including offices and data centers) with carbon-free energy around the clock by 2030. Furthermore, the project dedicated over $100,000 to Chowan County non-profits and community causes through its community grant program.

Farmers and landowners who host the wind turbines receive annual lease payments. These lease payments help inject the Chowan economy with millions of dollars to support local merchants, contactors, and equipment suppliers. The facility's anticipated lifespan is 30 years.

Implementation Timeline and Milestones

Timbermill Wind was issued a permit to begin construction in March 2023 and commenced construction in August 2023. By December 2024, Timbermill Wind became a fully operational, power producing offshore wind energy facility.

Metrics for Tracking Progress

Timbermill Wind will publish an annual Year in Review document for stakeholders, the first to be released in December 2025, and will contain data on the energy it produced. Subsequent report data will be captured in CPRG monitoring reports.

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[94] *Timbermill Wind, LLC. http://www.timbermillwind.com*

[95] *Southeastern Wind Coalition. (2025, July 27). After more than a decade in the making, Timbermill Wind is online. Retrieved from https://www.sewind.org/news/after-more-than-a-decade-in-the-making-timbermill-wind-is-onlline*

Measure Costs

Timbermill Wind cost approximately $218 million to construct. Of this project budget, over $45 million was allocated towards construction spending. Furthermore, the project will generate $33 million in cumulative county tax revenue during its 30-year lifetime.

Timbermill Wind provided an estimated one-time pulse of economic activity during the construction phase to support:

- 152 job years
- $5.5 million in associated labor income
- $19.8 million in economic output
- $505,103 in state and local tax revenue

During Timbermill Wind's operational phase, the facility will provide an estimated annual economic impact to Chowan County to support:

- 12 jobs (7 direct, 5 indirect/induced)
- $1.1 million in associated labor income
- $ 1.5 million in economic output

Intersection with Other Funding Availability

In August 2023, Apex Clean Energy and Google entered a power purchase agreement in which Google purchased the entirety of Timbermill Wind's 189 MW energy generating capacity. The energy generated from the wind farm will power Google's data centers within PJM, a regional transmission organization serving parts of 13 states and D.C.. The power purchase agreement will also support Google's goal to run completely on clean energy by 2030.[96]

Quantified GHG Emission Reduction

This section contains GHG emission reductions for all the projects discussed in this measure.

Measure 5-1. Residential solar installations for the EnergizeNC calculations estimate 43.4 MW of will be installed based on funding availability over the rollout of the program between 2025-2029. This value was entered into NREL's PVWatts calculator for an estimated 60,372,493 kWh/year, the lifetime of the panels is assumed to be 25 years, resulting in a total of

[96] *Apex Clean Energy. (2023, August 29). Apex and Google partner to advance North Carolina's second wind farm. Retrieved from https://www.apexcleanenergy.com/news/apex-and-google-partner-to-advance-north-carolinas-second-wind-farm/*

1,509,312,325 kWh. To derive the amount of $MTCO_2e$, EPA's eGrid Emission Factor 0.000303907 $MTCO_2e$/kWh, was used. This resulted in 18,348 $MTCO_2e$/year. Quantified data is in Table 20.

Measure 5-2. To avoid double counting, GHG emission reductions for the Wake Tech East Campus Central Energy plant are included in the USI estimates shown in Section 4.3.4.

Measure 5-3. At the current rate, Timbermill Wind is displacing 253,760 $MTCO_2e$, see Table 20. This displacement is anticipated to remain constant over the lifetime of the project (30 years). It is anticipated that this facility will support future data centers; however, the overarching benefits are unknown.

Table 21. Measure 5 - Quantified GHG Emission Reductions (MTCO2e)

Measure No.	Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
5-1	EnergizeNC	91,738	458,691
5-3	Timbermill Wind, LLC	253,760	253,760
	Total	**345,498**	**712,451**

Measure 6. Implement measures to increase energy resiliency in NC communities: Microgrids for North Carolina Resilience

Reliable electricity is essential for daily life in the U.S. and is directly linked to the stability of the power grid. When extreme weather events occur, like hurricanes, tornadoes, floods, winter storms, and wildfires, power grids are impacted, leaving residents without electricity, often for days or weeks at a time. From 1980-2024, there were 121 confirmed weather/climate disaster events with losses exceeding $1 billion each to affect North Carolina. These events included 13 drought events, 2 flooding events, 3 freeze events, 54 severe storm events, 31 tropical cyclone events, 2 wildfire events, and 16 winter storm events. From 1980-2020, North Carolina experienced an average of three extreme weather events each year. During the last four years, the state has experienced over seven extreme weather events per year, on average.[97]

On September 27, 2024, a devastating storm, Hurricane Helene, rolled through the southeastern U.S., eventually making its way up to Western North Carolina, parking over this part of the state unleashing unforeseen levels of flooding and devastation. NC Sustainable Energy Association's (NCSEA) Clean Energy Recovery proposal noted "[a]s it relates to grid infrastructure, many communities across Western NC, especially remote areas were without power, access to clean drinking water, and vital communications for weeks. In the immediate aftermath of Hurricane Helene, organizations on the ground like Footprint Project (FP)[98] and Land of Sky Regional Council (LOSRC)[99] were focused on delivering immediate relief through temporary microgrid solutions designed to bring power, water purification, and communications to communities in need."

Measure 6 aims to provide valuable resources to communities who have experienced power losses through microgrid solutions, starting with Western North Carolina. In collaboration with LOSRC, NCSEA, FP, and a deep network of regional partners, the NCDEQ is investing in permanent and mobile microgrids to provide flexible energy resilience in the aftermath of Hurricane Helene. Up to twenty-four stationary microgrids will be installed across six Helene-affected counties, and two mobile "Beehive"[100] microgrid hubs will be installed to serve the entire state of North Caroline during future disasters (one in Western North Carolina and one in Eastern North Carolina). This innovative approach to disaster recovery and resilience will improve emergency energy access for critical community services serving thousands of North Carolinians, in recovery from and preparation for future storms.

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[97] *NOAA. National Centers for Environmental Information. Billion-dollar weather and climate disasters. https://www.ncei.noaa.gov/access/billions/state-summary/NC*

[98] *NOAA. National Centers for Environmental Information. Billion-dollar weather and climate disasters. https://www.ncei.noaa.gov/access/billions/state-summary/NC*

[99] *https://www.landofsky.org/*

[100] *Beehive Microgrid. https://www.youtube.com/watch?v=Y_apblwKhOA*

Implementation Timelines and Milestones

The timeline for this measure is one year, 2025, as shown in Figure 14. If funds remain at the end of 2025, additional sites may be identified and resources deployed. Within 2025, approximately 20 sites will be selected, and resources installed for resiliency hubs plus the Beehive sites will be selected. Extensive community outreach and engagement will be conducted throughout the process so the surrounding residents will know where they can go for critical services during or after an extreme weather event.

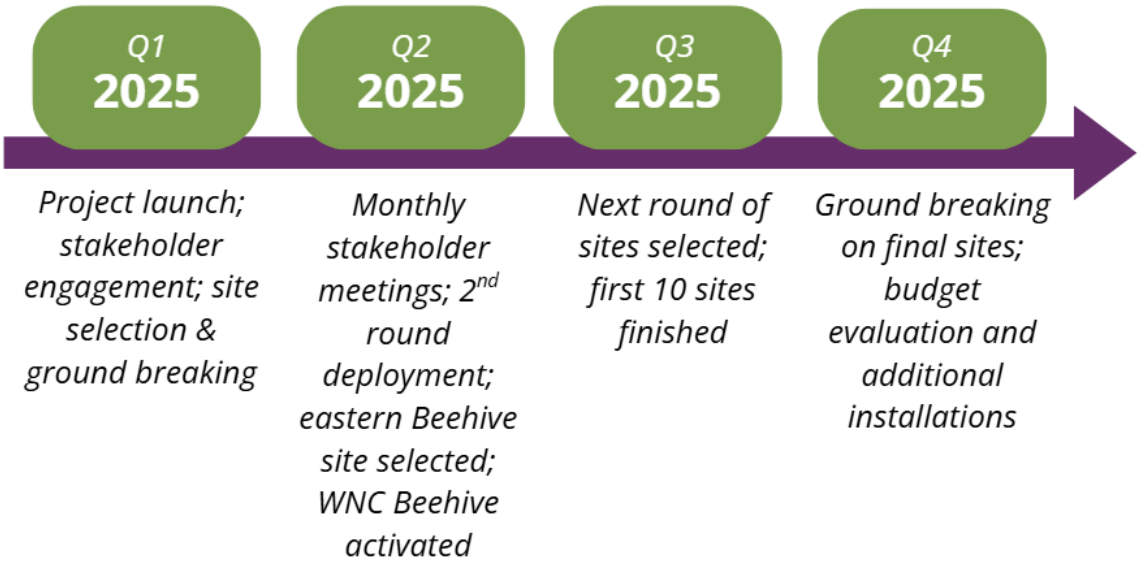

Figure 14. Measure 6 Implementation Timeline and Milestones

Metrics for Tracking Progress

- Outputs (Quantitative Data)
  - Number of facilities supported with resilient energy technologies through this grant.
  - Total kW of solar PV and kWh of battery storage installed.
  - Total estimated kW of solar produced through these installations.
  - Total estimated energy produced and consumed during power outage events.
- Granularity in power resiliency:
  - Ex: 100 facilities have uninterruptible power for communications, 20 facilities can provide indefinite food refrigeration in the event of prolonged grid failure.
- Estimated number of individuals who receive access to emergency services powered by grant-supported technologies during grey-sky and blue-sky scenarios.
- Regional coverage - population supported by facilities upgraded with resilient energy technologies.
- Estimated costs saved/provided through this intervention.
- Number of people trained on resilient microgrid technologies.

- Outcomes (Analysis and Qualitative Data)
- Improved resilience of critical facilities.
- Evaluate based on energy tiers as related to Maslow's hierarchy of needs and local/regional emergency management plans.
- Existing Resilience Scorecards:
- Geographical / Census-level:
- Baseline Resilience Indicators for Communities (BRIC)
- Communities Advancing Resilience Toolkit (CART)
- Improved ability of clients to deliver services during power outages.
- Testimonials from hub site leaders who use this grant's tech for their disaster resilience operations.
- Testimonials from individuals in the hub sites service territory who receive access to services powered by this grant's tech.
- Testimonials from community groups who use this grant's tech for non-disaster activities (education, outreach, events, etc.)
- Photos/Videos of installations and activations.
- Decibels reduction from gas diesel generator abatement -> reduced stress levels of responders/community members.

Measure Costs

Measure 6 is a pilot project and the budget allocates half of the $5,000,000 towards installing solar and battery microgrids on permanent resilience hub sites in six Helene-affected counties (Avery, Buncombe, Madison, Mitchell, Rutherford, Yancey), and allocating the other half towards installing two Beehive Microgrids (one in Western North Carolina and one in Eastern North Carolina) to flexibly serve the entire state of North Carolina, Table 22.[101] The final cost per installation is largely dependent on the site and facility energy needs, resilience goals, contractor bids, and in-kind equipment available for donation. Administrative costs cannot be billed to the project and have been estimated at 15% of the total cost.

[101] *U.S. Department of Energy. (n.d.). Grid Resilience and Innovation Partnerships (GRIP) Program. Retrieved from https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program-projects*

Table 22. Measure 6 Costs

Line Items	Item Qty	Item Cost	Total	Notes
Permanent Facility Microgrid Installations				
Small Facility	18	$75,000.00	$1,350,000.00	5-20kW Solar PV with 10-50kWh LFP Storage
Medium Facility	6	$150,000.00	$900,000.00	20-50kW Solar PV with 50-100kWh LFP Storage
Large Facility	1	$250,000.00	$250,000.00	50-100kW Solar PV with 50-200kWh LFP Storage
Equipment			**$2,500,000.00**	
Mobile Beehive Microgrid	2	$1,250,000.00	$2,500,000.00	See Appendix E for addition items listed
DIRECT COSTS			**$5,000,000.00**	
Administration, Insurance and Risk Mitigation		15%	$750,000.00	N/A can't be billed
TOTAL			**$5,750,000.00**	

Intersection with Other Funding Availability

- DOE Grid Resilience Program, BIL Section 40101(d).[102] NC has received $18.2M in funding for the first two years and will receive $8.6M for year three. The state is providing the required 15% match.
- DOE Grid Innovation Fund, GRIP Program. NC submitted three projects in funding round one but did not receive funds; NC has submitted two projects in round two.[103]
- Other DOE funding is available, including Grid Resilience Utility and Industry Grants, the Energy Improvements in Rural or Remote Areas Program, Transmission Siting and Economic Development (TSED) Grant Program, and other opportunities as shown at: https://www.energy.gov/gdo/grid-and-transmission-program-conductor.

[102] *U.S. Department of Energy. (2022). Grid Resilience 40101(d) Webinar. Retrieved from https://www.energy.gov/sites/default/files/2022-05/Grid-Resilience%2040101d%20Webinar%20Final%20%28web%29.pdf*

[103] *U.S. Department of Energy. (n.d.). Grid Resilience and Innovation Partnerships (GRIP) Program. Retrieved from https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program*

Quantified GHG Emission Reduction

The calculation for Measure 6 is based on an estimated 6,100 kW solar PV with 110 kWh LFP storage and an additional 10 kW PV solar for the beehive system to be installed. GHG reduction are below (Table 21). The lifetime of the system was assumed to last 25 years. For more details see Appendix E.

Table 23. Measure 6. GHG reductions for 2030 and 2050 (MTCO2e)

Measure Number-Title	2030 ($MTCO_2e$)	2030 ($MTCO_2e$)
6 - Microgrids for NC Resilience	13,157	65,784

4.3.4 Sector 3 Commercial and Residential Buildings Measures 7 and 8

One of the most effective ways in which to reduce GHG emissions from this sector is to reduce energy use in buildings. According to the U.S. Department of Energy (DOE), Americans spend 90% of their time in buildings, which use 74% of the nation's electricity and contribute to $370 billion in annual energy costs.[104] As North Carolina's population grows and its building stock ages, energy use in buildings is expected to rise. These factors will make efficiency improvements essential to reducing greenhouse gas emissions, lowering utility costs, strengthening resilience to extreme weather, and easing pressure on the electric grid. North Carolina's residential/commercial building sector accounted for approximately 7% of statewide GHG emissions, or 9.78 $MMTCO_2e$, according to the state's most recent inventory. Table 23 displays expected GHG reductions from implementing the building energy measures in this CCAP.

Buildings Key Take Aways

NCDEQ has developed and modeled two buildings measures that collectively will reduce GHG emissions by 38.7% by 2030 and 156.4% by 2050. They are:

Reduce the energy burden for low-income rural households by providing services that install insulation, air sealing, and HVAC upgrades as well as funding performance-based and whole-home retrofit strategies to achieve deeper energy savings. These actions result in 90,876 $MTCO_2e$ by 2030 and 736,196 $MTCO_2e$ by 2050 at an approximate cost of $217 million.

Increase energy efficiency in state-owned buildings, including government, commercial, industrial, institutional and residential, by conducting energy audits, installing equipment upgrades, improving energy management systems, weatherization, training, materials management, recycling, and other measures, for new and existing buildings. These actions result in 8,080,000 $MTCO_2e$ by 2030 and 34,750,000 $MTCO_2e$ by 2050 at an approximate cost of $25 million.

[104] *U.S. Department of Energy. (n.d.). Buildings energy efficiency. Retrieved from https://www.energy.gov/topics/buildings-energy-efficiency#:~:text=People%20spend%2090%25%20of%20their%20time%20in%20buildin%20%24370%20billion%20in%20annual%20energy%20costs.*

Table 24. Total GHG reductions in $MTCO_2e$ that can be implemented through Measures 7 and 8

Measure Number-Title	Short-Term Implementation Scenario Year 2030 Emissions ($MTCO_2e$)	Long-Term Implementation Scenario Year 2050 Emissions ($MTCO_2e$)
7 - Reduce per square foot energy usage in residential buildings in NC	90,876	736,196
8 - Decarbonize buildings in NC	8,080,000	34,750,000
Total	**8,170,876**	**35,486,196**

Implementation Authority

See Figure 8 Implementation Authority and Lead Agencies

Measure 7. Reduce per square foot energy usage in residential buildings in NC

Across the U.S., WAP supports approximately 8,500 jobs and weatherizes 32,000 homes each year. Energy Saver NC builds on this foundation by implementing DOE's Homeowners Managing Efficiency Savings (HOMES) and Home Electrification and Appliance Rebates (HEAR) programs, which fund performance-based and whole-home retrofit strategies to achieve deeper energy savings. Together, these programs help reduce emissions and improve comfort, health, and affordability in some of North Carolina's most energy-burdened communities.[105]

For this measure, North Carolina's Weatherization Assistance Program (WAP) and the Energy Saver NC initiative are programs that work to reduce the energy burden for low-income households while advancing the state's Residential and Commercial Buildings sector energy efficiency goals. WAP provides no-cost weatherization services to qualifying low-income households, such as insulation, air sealing, and HVAC upgrades, and delivers an average energy savings of $372 per home annually.[106] WAP implementation timeline can be seen below in Table 24.

Measure 7-1. North Carolina Weatherization Assistance Program (WAP)

In North Carolina, WAP serves to relieve low-income individuals of financial burdens associated with home energy efficiency upgrades, particularly high energy and housing costs. Eligibility for WAP includes both single family homes and multi-family units state-wide. Households must apply to the program to determine eligibility. WAP strives to reduce energy costs for low-

[105] *North Carolina Department of Environmental Quality. (n.d.). Weatherization Assistance Program. Retrieved from https://www.deq.nc.gov/energy-climate/state-energy-office/weatherization-assistance-program*

[107] *North Carolina Department of Environmental Quality. (n.d.). FY 25 Annual State Plan. Retrieved from https://www.deq.nc.gov/state-energy-office/state-north-carolina-weatherization-assistance-plan-program-fy2024-2025/download?attachment*

income households across the state and additionally provides the benefit of reduced carbon emissions and the promotion of jobs in clean energy.[107] WAP measures were assumed to reach 1,945 homes per year from 2025 through 2050, based on the historical average of annual completions. An additional 600 homes per year were modeled under the WAP program from 2025-2029, reflecting funding through the Bipartisan Infrastructure Law (BIL).

WAP seeks to install energy efficient measures in low-income households, in particular homes occupied by elderly, people with disabilities, and children. Energy efficiency measures implemented in qualified households include: 1) air sealing and insulation in single family homes, 2) replacing heat pumps, windows, and doors, 3) installing carbon monoxide and smoke detectors, 4) upgrading energy efficient lights, pipe insulation, and low-flow showerheads, 5) tuning, repairing, or replacing heating equipment, 6) testing for safety issues such as gas leaks and carbon monoxide, and 7) checking and repairing combustion appliances such as stoves, furnaces, and water heaters. All measures are inspected by a certified Quality Control Inspector at the conclusion of their installation to ensure work was done correctly and completely.

WAP relies heavily on plumbers, electricians, heating and cooling, and general contractors to carry out the program. As a result, the program continues to provide jobs that encourage energy efficiency across the state. With the necessity for alternative and clean energy sources on the rise, these job positions installing energy efficient measures will increase in demand.

Implementation Timeline and Milestones

Table 25. Measure 7-1 Implementation Timeline and Milestones for WAP

Measure No.	Timeline	Milestone
7-1	July 1, 2024-June 30, 2027	WAP funds began July 1, 2024 and end no later than June 30, 2027. After 2027, a new program cycle begins, and DOE begins nationwide applications for WAP funding.
7-1	Annually - Program Application	Funding is released to subgrantees on an annual basis. Subgrantees **must reapply annually** to SEO to receive WAP funding.
7-1	Annually - Reduce Number of Applicants on the Deferral Lists	Each year, WAP intends to reduce the deferral list applicants of single-family homes to allow

[107] *North Carolina Department of Environmental Quality. (n.d.). FY 25 Annual State Plan. Retrieved from https://www.deq.nc.gov/state-energy-office/state-north-carolina-weatherization-assistance-plan-program-fy2024-2025/download?attachment*

		those homes to be eligible for weatherization and provide multifamily deep retrofits.

Metrics for Tracking Progress

To ensure the program is compliant with the DOE and the NCDHHS, the following metrics in Table 25 are tracked to ensure progress.

Table 26. Metrics for Tracking Progress Measure 7-1 WAP

Measure No.	Metric	Frequency	Milestone
7-1	Audits	Annual	Annual monitoring is conducted by WAP to verify information received on monthly reports and to clarify questions raised by WAP and/or the Subgrantee.
7-1	Internal review	Monthly	All monthly reports are monitored by WAP to monitor compliance with the program's requirements, spending patterns, and chart program progress.
7-1	Site visits	Annual or as needed	These reviews may be conducted if any irregularities or questions are raised in the In-House review process that could not be resolved while In-House. On-Site reviews are conducted by a qualified WAP technician.
7-1	Subgrantee Post-Installation Inspection	Completed after each finished project	Each weatherized unit must be inspected by the Subgrantee's Quality Control Inspector to ensure the work complies with the required specifications before deemed completed.
7-1	Subgrantee Review	As needed	WAP will work with any Subgrantee to correct non-compliance, or any deficiencies with Low-Income Weatherization Program Implementation, Master Grant and/or federal rules and regulations.
7-1	Training and Technical Assistance	Annual or as needed	These activities are designed to maintain the efficiency, quality, and effectiveness of WAP. Training may be implemented in cases where corrected action is needed.

Measure Costs

In Table 26 is the total costs for Measure 7-1 NC Weatherization Assistance Program derived from the Department of Energy and the NC Department of Health and Human Services.

Table 2627. Total Measure Costs for Measure 7-1 WAP

Measure No.	Measure Title	Costs
7-1	North Carolina Weatherization Assistance Program (WAP)	$7,598,803

Measure 7-2. Energy Saver NC

In 2023, the DOE released its program guidelines for the HOMES and HEAR programs. Collectively, these programs are referred to Energy Saver NC.[108] Together, these programs allow North Carolina to strategically reduce energy burdens, decrease GHG emissions in low-income communities, and support achieving North Carolina's goal of reaching net zero GHG emissions by 2050, detailed in Table 27. The programs are designed to target residents in low-to-moderate-income-single-family dwellings in rural areas and help them make energy efficiency upgrades and electrify their homes. As a result, these homes achieve a lower energy burden and GHG emissions.

DEQ ensures DOE compliance for the rebate program through rigorous financial oversight, eligibility verification, and performance evaluation. Budget forecasting, financial tracking tools, and the DOE Rebate Tracking System—featuring duplicate coupon prevention and low-income household reserves—support rebate minimum adherence. Eligibility is confirmed using annually updated Area Median Income tables, trained staff, and verification methods. The program implementer manages applications, determines eligibility, issues rebates, trains contractors, and oversees data reporting. Contractors must submit detailed invoices, use approved ENERGY STAR equipment, and obtain NCDEQ approval before installation. NCDEQ collaborates with NREL, DOE, and utilities to analyze energy savings, non-energy benefits, and GHG reduction potential, while also tracking statewide emissions impacts. Annual evaluations include sampling completed projects to confirm modeled savings accuracy and comparing measured versus predicted savings to ensure program integrity and impact.

Energy Saver NC (HOMES) will provide rebates for whole home energy efficiency projects, such as upgrades to HVAC systems, heat pump installations and sealing/insulation. The project aims to reduce energy consumption and lower utility bills for North Carolina residents.

[108] *North Carolina Department of Environmental Quality. (n.d.). Energy Efficiency Rebates. Retrieved from https://www.deq.nc.gov/energy-climate/state-energy-office/inflation-reduction-act/energy-efficiency-rebates*

Energy Saver NC (HEAR) will provide rebates for high efficiency electric appliances such as heat pumps, electric stove tops, and electric clothes dryers. Non-appliance projects, such as electric wiring and circuit breaker panel upgrades, may also be eligible for rebates.

Implementation Timeline and Milestones

Table 28. Measure 7-2 Implementation Timeline and Milestones Energy Saver NC

Measure No.	Timeline	Milestone
7-2	Phase 1 – January 2025-26	Energy Saver NC will launch with Tranche 1 (a tranche is a definable phase of a project) funding (open to 25% of program spending). There will be focused outreach to low-income, single family rural residents.
7-2	Phase 2 – 2026-2028	Expand outreach to moderate-income and multi-family homes with Tranche 2 funding (open to 55% program spending).
7-2	Phase 3 – 2029-2031	Adjust program as needed to optimize market transformation using Tranche 3 funding (open up to 80% of program spending).

Metrics for Tracking Progress

NCDEQ's program is designed to ensure compliance with DOE requirements through robust tracking, verification, and evaluation processes. The program combines financial oversight, technology tools, contractor requirements, and collaborative analysis to verify eligibility, measure performance, and estimate both energy and non-energy benefits of rebate investments.

Key Program Components

- Financial & Compliance Oversight
  - Use of budget forecasting, financial tracking tools, and process controls to monitor rebate minimums and expenditures.
  - DOE Rebate Tracking System with coupon feature to:
    - Prevent duplicate coupons for the same address.
    - Allocate reserves for low-income single- and multi-family households.
  - Monthly review of line-item spending to identify and address over/underspending.
- Eligibility Verification
  - Annual updates to Area Median Income (AMI) reference tables for accurate income comparisons.
  - Use of trained staff and additional verification methods to prevent falsified applications.

- Program Implementer Responsibilities
    - Manage application processing, eligibility determinations, rebate issuance, communications, contractor training, data collection/reporting, and technical infrastructure for information sharing.
    - Collaborate on program braiding to maximize impact.
- Contractor Requirements
    - Submit detailed invoices with project costs, equipment model numbers, work addresses, and dates.
    - Use ENERGY STAR product finder for approved measures.
    - Obtain NCDEQ approval for ENERGY STAR-certified equipment prior to installation.
    - Provide product/equipment details, photos, and invoices post-installation to verify compliance.
- Collaboration & Data Analysis
    - Partner with NREL, DOE, and utility providers to:
        - Develop strategies for evaluating energy savings by time, location, and GHG emissions.
        - Analyze residential building stock and project impacts of efficiency improvements.
        - Estimate non-energy benefits such as GHG reduction potential and grid reliability.
        - Assess impacts of time-of-use rates on customer utility bills.
- GHG Tracking & Evaluation
    - Monitor and track estimated GHG reductions based on modeled energy savings.
    - Annual sampling of up to 10% of completed projects for modeled savings accuracy checks by compliance/audit staff.
    - Implementer reviews every home assessment for completeness and accuracy.
    - Annual impact evaluations include random sampling of single- and multi-family projects to compare measured versus predicted savings.

Measure Costs

Together, these programs provided over $198 million (see Table 28) to North Carolina to reduce energy burdens, decrease GHG emissions in communities, and support achieving North Carolina's goal of reaching net zero GHG emissions by 2050.

Table 29. Total Measure Costs for Measure 7-2 Energy Saver NC Program

Measure No.	Measure Title	Costs
7-2 a	Energy Saver NC (HOMES)	$99,583,424.11
7-2 b	Energy Saver NC (HEAR)	$99,232,128.38

	TOTAL	$198,815,552.49

Quantified GHG Emission Reduction

Statewide averages for annual North Carolina household energy consumption by fuel type were derived using statewide averages from EIA's Residential Energy Consumption Survey (RECS). Energy savings were then estimated as a percentage reduction in total household energy use based on program/market estimates and applied uniformly across fuels, including electricity, natural gas, and propane. These savings were subsequently converted to GHG emissions reductions see, Table 29. Please see Appendix E for EIA's Residential Energy Consumption Survey and for savings calculations that were converted to GHG emissions reductions for North Carlina WAP and Energy Saver NC.

Table 30. Measure 7 GHG Emission Reductions (MTCO2e)

Measure No.	Measure Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
7-1	WAP	38,878	458,872
7-2 a	Energy Saver NC (HOMES)	12,507	66,704
7-2 b	Energy Saver NC (HEAR)	39,491	210,620
	TOTAL for Measure 7	**90,876**	**736,196**

Intersection with Other Funding Availability

7-1 WAP

In North Carolina, WAP administers "Other Funds" for low-income weatherization received from NCDHHS and the General Assembly. These other funding opportunities include the Low-Income Home Energy Assistance Program (LIHEAP), the Heating Appliance Repair and Replacement Program (HARRP) and any additional funds designated for low-income weatherization awarded to the state resulting from legal settlements.[109,110] Subgrantees may also utilize funds from utility rebates, which are not administered by WAP, rather should be used to supplement a WAP-sponsored program.

As a result of the disastrous impacts of Hurricane Helene in September 2024, Governor Roy Cooper signed SL 2024-51 (The Disaster Recovery Act of 2024) on October 10, 2024, to provide initial recovery aid to western North Carolina. [111] Later that month, on October 25, 2024, Governor Cooper signed SL 2024-53 (The Disaster Recovery Act II of 2024), which provided additional funding for recovery efforts. As part of the Disaster Recovery Act II, the SEO is working with weatherization agencies to utilize the $10 million appropriated to assist low-income residents impacted by Hurricane Helene. [112]

7-2 Energy Saver NC

1. Integration with utility and federal programs
   Energy Saver NC intentionally bundles DOE-funded HOMES and HEAR rebates with existing utility incentives to simplify access for homeowners and contractors. The program also leverages federal rebates with Duke Energy's on-bill financing and similar programs from other utilities.
2. Stacking with IRS tax credits
   In addition to direct rebates, participants can claim complementary Energy Efficient Home Improvement Tax Credits and other state/local incentives (where applicable) possibly amplifying the financial benefits of combined upgrades.
3. Targeted support for WAP and low-income programs
   The HEAR program explicitly enables WAP-enrolled households to participate—even those on WAP waiting lists—while prohibiting double-dipping on the same upgrade

[109] *North Carolina Department of Health and Human Services. (n.d.). Low Income Energy Assistance Program (LIEAP). North Carolina Department of Health and Human Services. https://www.ncdhhs.gov/divisions/social-services/energy-assistance/low-income-energy-assistance-lieap*

[110] *North Carolina General Assembly. (n.d.). Heating and Air Repair and Replacement Program/LIHEAP. North Carolina General Assembly. https://www.ncleg.gov/ProgramEvaluation/ChildCouncil/Grant/148*

[111] *North Carolina General Assembly. (2024). Senate Bill 743 / SL 2024-53. North Carolina General Assembly. https://www.ncleg.gov/BillLookUp/2023/S743*

[112] *Office of Governor Roy Cooper. (2024, October 25). Governor Cooper signs one bill into law. Office of Governor Roy Cooper. https://governor.nc.gov/news/press-releases/2024/10/25/governor-cooper-signs-one-bill-law*

type. This ensures WAP customers can still access deeper rebates through Energy Saver NC.

Measure 8. Decarbonize buildings in NC, through replacement of fossil fuel combustion sources and other greenhouse gas emissions.

Measure 8 is aimed to increase energy efficiency in state-owned buildings, including government, commercial, industrial, institutional and residential, by conducting energy audits, installing equipment upgrades, improving energy management systems, weatherization, training, materials management, recycling, and other measures, for new buildings and existing buildings. Specifically, the Utility Savings Initiative (USI), established in 2002 by gubernatorial directive[113] and housed within the SEO, aims to achieve an Energy Use Intensity (EUI) reduction goal of 40% per square foot by 2025. Created in response to fiscal pressures and the need to reduce utility costs, USI provides technical assistance, data tracking, and strategic guidance to state agencies, universities, and other governmental units to identify and implement energy conservation measures.

Implementation Authority

See Figure 8 Implementation Authority and Lead Agencies

Implementation Timelines and Milestones

Measure 8 has been implemented for 23 years and will continue to be given resources and funding, see Table 30 for the timeline and milestones. An annual report is developed by the SEO, which details the EUI for public buildings.

Table 31. Measure 8 Implementation Timeline and Milestone

Measure No.	Title	Timeline	Milestones
8	Decarbonize buildings in NC - Utility Savings Initiative	2025-2031	40% reduction of EUI in Government Buildings

Metrics for Tracking Progress

Data collected from governmental units is utilized to generate a report that describes the Comprehensive Energy, Water, and Utility Use Conservation Program (i.e., the "Comprehensive Program") along with a summary of efficiency gains, as required every odd numbered year by statute. These data include electricity (kWh), natural gas (therms), No. 2 oil (gallons), No. 6 oil (gallons), and propane (gallons) utilization for each building. Additionally, in accordance with

[113] https://www.ncleg.gov/EnactedLegislation/Statutes/PDF/BySection/Chapter_143/GS_143-64.12.pdf

EO80, an annual status update is required for each cabinet agency's utility consumption, costs, and progress in reducing energy consumption.[114]

Quantified GHG Emission Reduction

Present projected GHG emission reductions (or enhancement of carbon sinks) from identified measures to the extent possible:

The USI calculates avoided greenhouse gas emissions by comparing annual energy use information (EUI) which is based on reported energy consumption and building square footage since 2001, against a 2001–2002 baseline, with projections extending through 2050. To align with the CPRG program, emissions are benchmarked to 2005 and calculated per fuel type using energy intensity trends, standardized square footage, and known emissions coefficients. Avoided emissions are determined by subtracting actual emissions from baseline emissions, then aggregated annually by fuel type to estimate total emissions reductions for target years 2030 and 2050, results are below in Table 31. Note, these emissions are likely an overestimation given the goals of the energy generation sector that lead to clean energy generation. These avoided emissions are based on North Carolina's current energy generation profile, which when further decarbonized would lead to greater avoided emissions overall.

Table 32. Measure 8 GHG Emission Reductions (MTCO2e)

Measure No.	Measure Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
8	Decarbonize buildings in NC - Utility Savings Initiative	8,080,000	34,750,000

Measure Costs

Typically, energy efficiency projects are designed to be self-financing, with costs repaid through guaranteed utility savings, ensuring no net increase to agency operating budgets. Expenses cover design, installation, verification, and maintenance. Some projects use repair and renovation (R&R) funds—up to $25 million in FY2023–24 for cabinet agencies with USI pre-approval—while others, like the UNC System, leverage carry forward funds from retained utility savings, creating a reinvestment loop that funds future upgrades such as LED lighting and water leak repairs.

Intersection with Other Funding Availability

The costs for this measure are generally neutral except for the recurring administrative costs that the program receives from the NC General Assembly in a biannual budget bill, estimated at $200,000.

[114] *North Carolina Department of Environmental Quality. (2023). Comprehensive Energy, Water, and Utility Use Conservation Program Report. North Carolina Department of Environmental Quality. https://www.deq.nc.gov/legislative-reports/comprehensive-energy-water-and-utility-use-conservation-program-report/open*

4.3.5 Sector 4 Industry Measure 9

North Carolina's industrial sector accounts for approximately 13% of statewide GHG emissions, or 16.45 $MMTCO_2e$ as of 2020, according to the state's most recent inventory. Under a BAU, emissions are projected to increase to 19.43 $MMTCO_2e$ by 2030 and 21.63 $MMTCO_2e$ by 2050.

Measure 9. Industrial Decarbonization Planning and Opportunity Analysis (Unfunded).

Although the state does not have regulatory authority over most industrial emissions sources, North Carolina's PCAP identified this sector as a critical area and proposed a set of strategies that could support decarbonization over time. These included:

1. Industrial Electrification, Efficiency, and Process Emissions Reduction
2. Industrial Decarbonization Workforce Development
3. An Industrial Decarbonization Loan Fund

The PCAP estimated that, if implemented, these strategies could reduce emissions by up to 2.1 $MMTCO_2e$ by 2030 and 10.5 $MMTCO_2e$ by 2050, relative to BAU projections. The implementation grant proposal included a request for $15 million to support early-stage efforts, with sub-measure 1 identified as the most cost-effective pathway.

However, this measure remains unfunded in the absence of an EPA implementation award. The CCAP therefore includes this measure to document the need and readiness for industrial decarbonization efforts, should resources become available.

Industrial stakeholders in North Carolina have emphasized that capital investments in electrification, low-carbon fuels, and process improvements are unlikely to occur unless they result in near-term cost savings or are offset by financial incentives. Energy efficiency measures are often pursued only when they directly reduce operational costs—GHG reductions alone are typically not a sufficient motivator. As noted in the Funding North Carolina's Clean Energy Future report[3], developed by the Nicholas Institute and the Coalition for Green Capital, "By providing technical assistance

Industry Key Take Aways

NCDEQ did not further develop measures for the industrial sector due to insufficient funding; rather, we rely on the estimates calculated in the PCAP to showcase GHG emission reductions that could be achieved given adequate resources.

The PCAP estimated that, if implemented, these strategies could reduce emissions by up to 2.1 $MMTCO_2e$ in 2030 and 10.5 $MMTCO_2e$ in 2050, relative to BAU projections at a cost of $15 million to support early-stage efforts.

Industrial stakeholders in NC have emphasized that capital investments in electrification, low-carbon fuels, and process improvements are unlikely to occur unless they result in near-term cost savings or are offset by financial incentives. Additionally, lack of skilled personnel to maintain new systems is a challenge.

and credit enhancements, the state can reduce risk and encourage investment that would otherwise be cost-prohibitive." The report concludes that without clearer market signals and accessible support, industrial actors are unlikely to voluntarily pursue decarbonization strategies at the scale needed to significantly reduce GHG emissions from this sector.

Workforce availability is another persistent barrier. Industry representatives have reported that energy-efficient equipment upgrades, and onsite system improvements are often delayed or deprioritized due to the lack of skilled personnel available to implement and maintain new systems without disrupting production. Addressing these workforce limitations in HVAC, process controls, and industrial maintenance remains essential for enabling broader adoption of GHG emission reducing practices.

In summary, without funding or workforce development, this sector will continue to increase GHG emissions which impact the economy-wide achievement of net-zero emissions by the 2050 target. Nonetheless, NCDEQ will continue to support voluntary industrial decarbonization by sharing data, coordinating with federal and regional programs, and serving as a resource for technical planning and partnership development.

Implementation Authority and Responsibilities

NCDEQ does not have regulatory authority over industrial energy systems, fuel use, or emissions beyond existing federal permitting programs. As a result, implementation of this measure would be voluntary and driven by private-sector action.

However, as part of North Carolina's CPRG-funded planning activities, NCDEQ developed an Implementation Workplan for the industrial sector. That workplan identified a set of potential projects that focused on industrial electrification, process improvements, workforce development, and a decarbonization loan fund. These projects were designed to deliver measurable GHG reductions if supported through future funding.

The state's role in this sector is primarily advisory and facilitative. NCDEQ can support voluntary industrial decarbonization by providing technical data, convening partners, sharing funding and incentive information, and coordinating across agencies and regions. This measure is included in the CCAP to document sector opportunities and reflect NCDEQ's planning readiness to support emissions reductions when resources and private-sector willingness align.

Measure Costs

While Measure 9 is not currently funded or implemented, cost estimates were developed during North Carolina's CPRG planning phase and included in the state's Implementation

Workplan. These estimates represent the anticipated costs of launching a set of voluntary industrial decarbonization programs over a five-year period, should future funding become available.

The Implementation Workplan included three sub-measures:

1. Industrial Electrification, Efficiency, and Process Emissions Reduction
2. Industrial Decarbonization Workforce Development
3. Industrial Decarbonization Loan Fund

The total estimated cost to implement these programs was $15 million over five years. This figure includes a mix of capital investments, workforce training programs, administrative support, and technical assistance. The most cost-effective of the three, sub-measure 1, was projected to enable low-cost energy efficiency upgrades in high-energy-use facilities, yielding early emissions reductions ("low-hanging fruit").

These estimates were developed using assumptions from stakeholder input, prior grant-funded project budgets, and available program cost data from state energy and workforce programs. No cost-benefit analysis or lifecycle modeling was performed for this measure due to its unfunded status, but NCDEQ intends to update these estimates should funding opportunities emerge.

Because implementation would rely on voluntary private-sector participation, actual costs and emissions impacts would vary depending on program uptake, sectoral trends, and prevailing market conditions.

Intersection with Other Funding Availability

No funding has been secured for this measure to date. However, North Carolina submitted an EPA Implementation Grant application under the CPRG program that included funding for Measure 9 and its three sub-measures. The request totaled $15 million over five years and was not awarded.

The state continues to monitor federal funding opportunities that could support industrial decarbonization, including:

- DOC's NC Manufacturing Extension Partnership[115]

[115] *https://ies.ncsu.edu/wp-content/uploads/sites/15/2024/11/SMARTER-NC-Flyer.pdf*

- DOE's Industrial Efficiency and Decarbonization Office (IEDO) programs[116]
- DOE's Office of State and Community Energy Programs (SCEP)[117]
- Greenhouse Gas Reduction Fund (GGRF)–supported financing mechanisms, including those operated by national nonprofit green banks[118]
- State Energy Program (SEP) and formula funds available to NC through existing DOE/state agreements[119]

While no active applications are pending at this time, the activities outlined in this measure remain viable for future funding requests as opportunities emerge. NCDEQ may also coordinate with other state agencies, such as the Department of Commerce or the NC Community College System, to support workforce development components of this measure if complementary funding becomes available.

[116] *U.S. Department of Energy. (2024). FY24 Energy and Emissions Intensive Industries FOA. U.S. Department of Energy. https://www.energy.gov/eere/iedo/iedo-fy24-energy-and-emissions-intensive-industries-foa*
[117] *U.S. Department of Energy. (n.d.). Office of State and Community Energy Programs. U.S. Department of Energy. https://www.energy.gov/scep/office-state-and-community-energy-programs*
[118] *U.S. Environmental Protection Agency. (2024, August 16). EPA awards $27B in Greenhouse Gas Reduction Fund grants to accelerate clean energy solutions. U.S. Environmental Protection Agency. https://www.epa.gov/newsreleases/epa-awards-27b-greenhouse-gas-reduction-fund-grants-accelerate-clean-energy-solutions*
[119] *U.S. Department of Energy. (2024). State Energy Program Operations Manual. U.S. Department of Energy. https://www.energy.gov/sites/default/files/2024-12/scep-sep-operations-manual-2024.pdf*

4.3.6 Sector 5 Waste Measures 10 - 12

The waste sector includes many management aspects that can be sources of GHG emissions. These include fugitive emissions from a municipal solid waste (MSW) landfill itself to refuse trucks that collect trash. MSW landfills manage various non-hazardous household and commercial waste. Waste materials that are biodegradable will eventually break down anaerobically (in the absence of oxygen) to methane, carbon dioxide, and water. Wastes that are not biodegradable (e.g., plastics, glass, metals) will not produce GHGs and will stay intact in the landfill. This process produces GHGs, mainly methane and carbon dioxide. Methane is the primary concern because it has a much higher global warming potential than carbon dioxide. Methane emissions can be converted to CO_2 using a global warming potential (GWP).[120,121] Since methane emissions have a higher GWP than CO_2, it is important to reduce these emissions to the greatest extent possible.

In the U.S., landfills are the third-largest source of anthropogenic methane emissions, generating 119.8 $MMTCO_2e$ and accounting for 17.1% of total methane emissions.[122] Direct GHG emissions from North Carolina's waste sector accounted for approximately 5% of statewide GHG emissions, or 7.17 $MMTCO_2e$, according to the state's latest GHG inventory.

Table 32 shows the estimated total GHG reductions in $MTCO_2e$ that can be implemented through Measures 10 and 12.

WASTE Key Take Aways

NCDEQ has developed and modeled three measures for the waste sector that collectively will reduce GHG emissions by 17% by 2030 and 25.3% by 2050. These include:

Divert food from the waste system to reduce methane emissions by installing food donation refrigerators in schools, transferring excess food to food banks, expanding compost facility capacity and improving education.

Refuse truck fleet change-over to low carbon emitting or EVs (the GHG emissions for this measure are included in the Transportation sector Measure 1).

Reduce landfill gas emissions through gas collection systems and landfill covers.

[120] *Global Warming Potential (GWP) is a metric that compares the warming effect of different greenhouse gases to that of carbon dioxide (CO2). Specifically, it quantifies how much heat a given mass of a gas traps in the atmosphere over a specified time period, relative to the same mass of CO2. Gases with higher GWPs trap more heat and contribute more to global warming than gases with lower GWPs*[121] *https://www.epa.gov/ghgemissions/understanding-global-warming-potentials#:~:text=Chlorofluorocarbons%20(CFCs)%2C%20hydrofluorocarbons%20(HFCs)%2C%20hydrochlorofluorocarbons%20(HCFCs)%2C%20perfluorocarbons,atmosphere%20for%20hundreds%20or%20thousands%20of%20years.*

[121] *https://www.epa.gov/ghgemissions/understanding-global-warming-potentials#:~:text=Chlorofluorocarbons%20(CFCs)%2C%20hydrofluorocarbons%20(HFCs)%2C%20hydrochlorofluorocarbons%20(HCFCs)%2C%20perfluorocarbons,atmosphere%20for%20hundreds%20or%20thousands%20of%20years.*

[122] *U.S. Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022. EPA 430-R-24-003. Washington, DC: U.S. Environmental Protection Agency, April 2024.*

Table 33. Total GHG reductions in $MTCO_2e$ that can be implemented through Measures 10 and 12

Measure Number-Title	Short-Term Implementation Scenario Year 2030 Emissions ($MTCO_2e$)	Long-Term Implementation Scenario Year 2050 Emissions ($MTCO_2e$)
10 - Reduce food waste	1,234,674.63	1,234,674.63
12 - Reduce landfill gas emissions	36,453	781,359
Total	**1,272,127.63**	**2,016,033.63**

NOTE: Emissions for Measure 11 are accounted for in Measure 1.

Implementation Authority and Responsibilities

Figure 8 Implementation Authority and Lead Agencies

Measure 10. Reduce food waste entering the waste management system to reduce the methane emissions from food waste landfilling, direct food to communities in need, and create organic resources through composting.

In the U.S., landfills are the third-largest source of anthropogenic methane emissions, generating 119.8 $MMTCO_2e$ and accounting for 17.1% of total methane emissions.[123] According to the EPA, each year wasted food in the United States produces the same GHG emissions as 42 coal-fired power plants and uses enough water and energy to supply 50 million homes.

North Carolina generated about 2.66 million tons of food waste in 2023, while 1.49 million people in the state faced hunger in 2024.[124] When individuals, businesses, non-profit organizations, and local governments reduce food waste, they lower their environmental impact, save money, and are able to feed their community. This measure includes actions involving enhanced food recovery programs in communities and schools, increased food waste composting capacity and efforts, and considerations for more landfill gas collection in NC landfills. The actions within this measure are geographically focused on North Carolina with specific emphasis on food insecure communities.

Implementation Timelines and Milestones

This measure is still in its infancy and what is described here are activities that may be used to implement this measure include, but not limited to:

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[123] U.S. Environmental Protection Agency. (2024). https://www.epa.gov/lmop/frequent-questions-about-landfill-gas[124] North Carolina Department of Environmental Quality. (2023). The Impact of Food Waste. Use The Food NC. https://www.deq.nc.gov/about/divisions/environmental-assistance-and-customer-service/recycling-and-materials-management/use-food-nc

[124] North Carolina Department of Environmental Quality. (2023). The Impact of Food Waste. Use The Food NC. https://www.deq.nc.gov/about/divisions/environmental-assistance-and-customer-service/recycling-and-materials-management/use-food-nc

- **Install food donation refrigerators in schools**: Facilitate outreach programs in counties without a refrigerator program to enable a community donation project to raise funds for the refrigerators as well as establish a volunteer base to monitor the refrigerators once installed. Additionally, solicit proposals for other related projects and means to accomplish this goal. This can be established both within the scope of individual schools and districts to install refrigerators at schools.
- **Transfer excess food to food banks**: Establish or expand partnerships and collaboration efforts between food surplus producers like farms, stores, and restaurants to facilitate more excess food to food banks. Solicit proposals for pilot programs across NC.
- **Deploy food waste collection programs**: Residential and business organics collection, digestion, and composting pilot programs should be implemented at the city and county-level throughout the state, modeling the Compost Now and Wilmington Compost Company's operation. This can be through partnerships with existing programs or implementing state-level infrastructure.[125] Diverting these wastes from going to a landfill would avoid fugitive emissions from landfills.
- **Expand compost facility capacity**: Provide funding for existing compost facility expansion and increase new local facilities will encourage growth in this sector and reduce transportation pressure of operations.
- **Educate**: Enhance environmental educational outreach in schools, local governments, and community organizers to facilitate a unified effort to reduce food waste in homes, businesses, and schools. This can be done by expanding website educational tools, hosting seminars, posting flyers, and hosting related events.
- **Recommend and encourage** local governments to establish goals that align with North Carolina's involvement in the reduction of GHG emissions and disrupting the flow of waste entering the landfills.

Metrics for Tracking Progress

Examples include:

- Amount of food waste diverted from landfills through compost drop-off and pick-up programs
- Number of students receiving diverted food
- Number of schools with a compost or food recovery program
- Policies and procedures adopted by communities
- Avoided GHG emissions.[126]

[125] *North Carolina Department of Environmental Quality. (2024, March). North Carolina Priority Climate Action Plan. U.S Environmental Protection Agency. pp. 73,74. https://www.deq.nc.gov/north-carolina-priority-climate-action-plan-climate-pollution-reduction-grant/open*

[126] *North Carolina Department of Environmental Quality. (2024, March). North Carolina Priority Climate Action Plan. U.S Environmental Protection Agency. pp. 73,74. https://www.deq.nc.gov/north-carolina-priority-climate-action-plan-climate-pollution-reduction-grant/open*

Quantified GHG Emission Reduction

Avoided emissions from food diversion programs were calculated from data collected through research of existing food collection programs, surveys, and interviews of experts in the waste industry. There are 24 locations in the state that collect food through composting or recovery programs at schools, cities and counties. The GHG reduction estimates were determined based on a weight basis (tons/year) using EPA's Waste Reduction Model (WARM). See Appendix E for methods.

The presented values below (Table 33) represent the avoided and reduced GHG emissions due to composting and food recovery projects in North Carolina. The total emissions reduced is assumed constant over time because the project will be completed before 2050.

Table 34. Measure 10 GHG Emission Reductions (MTCO2e)

Measure Number-Title	2030 ($MTCO_2e$)	2030 ($MTCO_2e$)
10 - Reduce food waste	1,234,674.63	1,234,674.63

Measure Costs

Recovery and donation programs like food banks are typically low cost with the price being administrative cost within the organization. For example, the Guilford County refrigerator project was 100% community funded with donations and volunteer work to install them. Compost programs can have a wide range of costs involving administration, equipment and transportation. Compost Now, a prominent B-Corp non-profit organization that conducts food waste collection in many communities in NC, started their operation with $300,000 from various investors and grants and was able to grow significantly in the last few years.[127] A school compost program is much less costly and can range from a few hundred dollars for bins to use compost in their school garden to $8,000 to start a large school program with pick-up. Many school compost programs in NC decreased the amount of trash pick-up and the money saved was put towards compost costs.[128] These costs can be funded through a grant and supported through community and student involvement, as well as volunteers.

Programs Currently Funded by the NCDEQ[129]

- Multifamily Recycling Grant Program
- Recycling Business Development Grants
- Food Waste Reduction Grant

[127] *WRAL TechWire. (2017, November 30). Earth friendly startup CompostNow raises $300,000 from investors. https://wraltechwire.com/2017/11/30/earth-friendly-startup-compostnow-raises-300000-from-investors-video/*
[128] *Sanchez, G. (2024, March 11). Reopened: Grants for your school to stop food waste and start composting!. Clean Water Action. https://cleanwater.org/2024/03/11/reopened-grants-your-school-stop-food-waste-and-start-composting*
[129] *North Carolina Department of Environmental Quality. (2025b). Grants. NC DEQ. https://www.deq.nc.gov/news/grants*

- Community Waste Reduction and Recycling Grant Program

Intersection with Other Funding Availability

- The Composting Food Waste Reduction Program (CFWR) through the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) provides funding for municipalities, counties, local governments, or city planners who are conducting a project involving compost, improving soil quality, waste management, permaculture business development, increasing rainwater, reducing municipal food waste, and diverting food waste from landfills. This grant will match 25% of the total project costs.[130]
- The Solid Waste Infrastructure for Recycling Grants for Communities (SWIFR): a grant through the EPA Bipartisan Infrastructure Law and supports local governments to advance reuse, recycle, composting, and anaerobic digestion projects.[131]
- The Community College Food Recovery Grant: a grant funded by the Food Recovery Network that has a value of $5,000 to $20,000 given to community colleges to support one year of technical and financial assistance to set up 25 food recovery programs on their campus.[132]
- The Community Waste Reduction and Recycling Grant Program: an NCDEQ funded grant with a value of up to $40,000 depending on the project and is for local governments to grow and expand efficient and effective waste reduction and recycling service in NC.[133]
- The BPI Composting Microgrants: a grant with a value range of $500 to $5,000 for companies supporting food waste management and compositing to promote best practices for the use and successful diversion and process of compostable products and increase in food waste collection.[134]
- The NCCC Grant is through the North Carolina Composting Council: a grant with a value of $2,000 to individuals and groups applying for assistance with projects that are furthering composting, compost-use, or compost education in NC.[135]
- The Community Food Projects Competitive Grant Program (CFPCGP): a grant that funds projects that include food insecure community members in the planning, designing,

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[130] *U.S. Department of Agriculture. (2023). FY2023 CFWR composting and Food Waste Reduction Program faqs. Composting and Food Waste Reduction (CFWR). https://www.usda.gov/farming-and-ranching/agricultural-education-and-outreach/urban-agriculture-and-innovative-production/composting-and-food-waste-reduction-cfwr-cooperative-agreements/fy2023-cfwr-composting-and-food-waste-reduction-program-faqs*

[131] *U.S. Environmental Protection Agency. (2025, March). Solid Waste Infrastructure for Recycling Grant Program. https://www.epa.gov/infrastructure/solid-waste-infrastructure-recycling-grant-program*

[132] *Food Recovery Network. (2024). Community colleges. https://www.foodrecoverynetwork.org/communitycolleges*

[133] *North Carolina Department of Environmental Quality. (2025). Grant application forms. NC DEQ. https://www.deq.nc.gov/about/divisions/environmental-assistance-and-customer-service/recycling-and-materials-management/programs-offered/grants-local-governments*

[134] *BPI. (2025). BPI Composting Microgrants. BPIWorld. https://bpiworld.org/bpi-composting-microgrants*

[135] *North Carolina Composting Council. (2024, January 20). Grants. NCCC. https://carolinacompost.com/grants/*

development, implementation and evaluation of activities, services, programs, and policies to combat food and nutrition insecurity.[136]

Measure 11. Decarbonize waste collection to reduce GHG emissions during the collection and transport of wastes through electrification of fleets or through engine conversion from diesel to electric motors

Reducing GHG emissions from waste collection vehicles (e.g. refuse trucks) is important in the communities where the trucks travel and at the landfill where the trash is ultimately deposited. Diesel powered vehicles produce both carbon dioxide, nitrogen oxide, and many other harmful particulate matter. Due to the stop-and-go nature and the onboard equipment of refuse collection trucks, they consume significantly more than the average gas-powered car or truck on the road. Nationally, refuse trucks consume as much as 1.2 billion gallons of diesel each year.[137] Converting conventional diesel fueled trucks to an EV fleet or to other low-carbon fuels (e.g. compressed natural gas or renewable natural gas) is occurring through programs described in the Transportation sector – Measure 1.

Quantified GHG Emission Reduction

GHG emission reductions for this measure are included in the calculations for Measure 1. They are not included here to avoid double counting.

Measure 12: Reduce landfill gas emissions through improved landfill operations to collect gas more efficiently and earlier in a landfill life

MSW landfills sometimes include systems to control methane emissions. Without controls, methane migrates through the landfill and escapes through the surface and into the atmosphere.

Methane emissions are the greatest while the MSW is in operation. To increase methane collection efficiency, thereby reducing GHG emissions, a transitional cover system can be installed. [138,139] Installing transitional covers, in combination with gas collection systems, improves methane capture efficiency. This approach reduces fugitive emissions, increases gas available for beneficial use, and extends the effectiveness of existing systems.

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[136] *U.S. Department of Agriculture. (2025). Community Food Projects Competitive Grant Program (CFPCGP). National Institute of Food and Agriculture. https://www.nifa.usda.gov/grants/programs/hunger-food-security-programs/community-food-projects-competitive-grant-program-cfpcgp*

[137] *Yang Zhao, Omer Tatari. (2017). Carbon and energy footprints of refuse collection trucks: A hybrid life cycle evaluation, Sustainable Production and Consumption. Volume 12, p. 180-192. ISSN 2352-5509, https://doi.org/10.1016/j.spc.2017.07.005. https://www.sciencedirect.com/science/article/pii/S235255091730026X*

[138] *Waste Today. (2019). How landfill covers can help improve operations. Wastetodaymagazine.com. https://www.wastetodaymagazine.com/news/interim-daily-landfill-covers/*

[139] *U.S. Environmental Protection Agency, & Gross, B. A. (n.d.). Landfill Cover Landfill Cover Design and Operation - USEPA Workshop on Bioreactor Landfills. EPA. https://archive.epa.gov/epawaste/nonhaz/municipal/web/pdf/gross.pdf*

Transitional covers are temporary systems placed on sections of a landfill that are no longer receiving waste but are not yet ready for final closure. They improve gas collection efficiency during the years when methane emissions are at their highest, often using geomembranes or compacted soils to reduce infiltration and surface leaks. When a landfill closes, a final cover, called an engineered cover, is installed. Engineered covers are permanent and limit infiltration, control erosion, and provide long-term gas containment. Together, both types of landfill covers provide complementary benefits. Transitional covers support near-term methane reductions by boosting collection efficiency during active years, while final covers deliver long-term control and regulatory compliance, ensuring sustained reductions after landfill operations end.

When a landfill closes, a final cover is installed. To better understand current practices and opportunities, NCDEQ conducted a statewide survey of landfill operators. The results provide insight into existing cover types, methane collection systems, and barriers to upgrades, and they helped guide the selection of landfills for modeling.

Statewide Survey of Landfill Practices

NCDEQ surveyed landfill operators across North Carolina about their current and planned use of transitional engineered covers and gas collection systems. The survey received 29 responses from counties across the state, including both municipal solid waste facilities and construction and demolition debris landfills. The responses showed wide variation in current practices. Six facilities reported having an engineered final cover, eight reported a partial final cover, and 14 reported no engineered final cover. Three landfills indicated plans to install or upgrade a cover within the next five years, while most were unsure or had no plans.

The survey asked operators the following questions and gave respondents the option of adding additional comments or suggestions:

1. Does your landfill have a methane collection or control system?
2. Are you considering future methane emission upgrades?
3. What are the biggest challenges to landfill cover upgrades?
4. Are you interested in decarbonizing your waste collection fleet through electrification or engine conversion?
5. What additional support would be helpful?

EPA maintains national landfill datasets through the Greenhouse Gas Reporting Program (GHGRP) and the Landfill Methane Outreach Program (LMOP), but these primarily track emissions and gas-to-energy projects at larger facilities. They do not provide state-specific information on cover types, operator intentions, or practical barriers to upgrades. The NCDEQ survey attempts to add some local detail on practices and challenges across a range of facilities, including smaller landfills that do not report to EPA.

The responses showed wide variation in current practices. They provide insight into current landfill practices, challenges, and interest in future methane reduction measures. Key findings include:

1. Final Cover Status
    - Fourteen facilities reported having no engineered cover.
    - Eight reported only having a partial cover.
    - Six reported installing an engineered cover.
    - One facility was unsure of their type of cover.
    - Three facilities indicated plans to install or upgrade within the next five years.

2. Methane Control Systems
    - Fifteen facilities reported no methane control systems.
    - Eight reported having an active system.
    - Five reported a passive system.
    - One facility was unsure if there was any methane control system.

3. Barriers to Cover Upgrades
    - Cost was the most frequently cited barrier to cover upgrades.
    - Lack of staff capacity, technical feasibility, and permitting uncertainty were also stated as challenges to installing cover upgrades.

4. Future Interest in Methane Reduction
    - Seven facilities expressed interest in early gas collection systems.
    - Four facilities are interested in some type of system improvements.
    - Several facilities stated interests in other measures (e.g., flowmeters, gas-to-energy).
    - Fifteen facilities reported no current plans for any methane reduction systems.

These survey results show that while opportunities exist to expand the use of covers and gas collection systems, many landfills will need technical assistance and financial support to move forward. The survey also provided the basis for selecting three landfills—New Hanover County, Anson County, and Surry County—for more detailed modeling of potential methane reductions.

The key implementing agency for this measure is NCDEQ. The regional coordination and implementation support involves public and private land management entities. The actions within this measure are geographically focused on the state of North Carolina with specific emphasis on landfills and the surrounding communities.

Implementation Timelines and Milestones

This measure is still in its infancy and what is described here are activities that may be used to implement this measure include, but are not limited to:

- Provide guidance and education to landfill operators about their options involved in improving their GHG emission reduction potential
- Make GHG collection efficient covers more accessible to smaller landfills through funding and support

- Facilitate partnerships between landfills and local compost programs for more cost-efficient covers

Milestone 1: Acquire support from NC landfill operators to encourage action and cooperation with the goals of this measure through education and community engagement

Milestone 2: Conduct an aerial survey and LandGEM studies to identify the highest landfill emitters and a complete inventory of what type of covers are currently used.

Milestone 3: Initiate a pilot-period for 3-5 landfill sites and monitor for functionality and effectiveness to reduce GHG emissions.

Millstone 4: Expand landfill biocover installations based on emissions, risk, and readiness to the rest of the landfills in the state.

Metrics for Tracking Progress

- Number of total landfills with plans for more efficient GHG collection covers and practices
- Number of landfills that have installed new or upgraded emission reducing covers
- GHG emission reductions (Table 34)

Quantified GHG Emission Reduction

Table 3435. Measure 12 GHG Emission Reductions (MTCO2e)

Measure Number - Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
12 – Reduce landfill gas emissions	36,453	781,359

NCDEQ identified candidate landfills through a statewide operator survey and selected three for detailed modeling: New Hanover County, Anson County, and Surry County. These landfills responded to the survey and indicated interest in installing or upgrading cover and gas collection systems. Cleveland County landfill was also included as an assumed case for both a new cover and a new gas collection system.

EPA's GHGRP FLIGHT tool provided baseline methane emissions data for the selected sites. A BAU projection of methane emissions through 2050 was developed using a population growth factor to account for expected increases in waste generation.

For the improved scenario, NCDEQ assumed that transitional covers would be installed beginning in 2030, reflecting a realistic implementation timeline. Research indicates that transitional covers increase gas collection efficiency by approximately 15 percent.[140] This

[140] *Sullivan, P. (2015). Early Implementation of Landfill Gas Collection and Control Systems Significantly Reduces Emissions. SWANA Landfill Gas Symposium, San Antonio, TX. Available at: https://www.scsengineers.com/wp-content/uploads/2015/03/Sullivan_SWICS_White_Paper_Version_2.2_Final.pdf*

percentage improvement was applied to BAU emissions starting in 2030 to estimate reductions.

The analysis shows that transitional covers and improved gas collection systems can achieve measurable methane reductions during the years when landfill emissions are at their highest. Methane is converted to CO2 when it is combusted, and while CO2 is a GHG, its GWP is lower than methane which reduces the overall climate impact than if methane is emitted directly. When landfill gas is used for energy generation, it also offsets the use of fossil fuels, providing an additional emissions benefit. Results from the modeled sites are presented as illustrative examples. Statewide reductions would be greater if more landfills would install or upgrade cover and collection systems.

Measure Costs

To accomplish this measure and decrease GHG emissions from landfills, funding for planning, installation, and management is required to best support the landfill operators of North Carolina. According to the EPA, the cost for the installation of a Biocover is approximately $48,000 per acre of landfill. Additionally, funding is required for planning and management.

Intersection with Other Funding Availability

There are 14 landfills that are either candidates for or have high future potential for a new gas collection project. Of those 14, 7 are already planned or in construction, and 27 other landfills have some level of gas collection already at their landfill. For example, the White Street Landfill in Greensboro is about 890 acres and directly reduces 0.602 $MTCO_2e$ each year with their reciprocating engine and intermediate cover.[141]

- **Solid Waste Infrastructure for Recycling Grant Program:** a grant for counties, cities, towns, parishes, and similar units of government. It provides funds to implement the National Recycling Strategy to improve post-consumer materials management and infrastructure; support improvements to local post-consumer materials management and recycling programs; and assist local waste management authorities in making improvements to local waste management systems.[142]
- **Solid Waste Infrastructure for Recycling Grants for States and Territories:** a grant for states, territories, and the District of Columbia. It funds activities that improve solid waste management planning, data collection, and program implementation, including composting.
- **USDA Solid Waste Management Grant:** a grant for public bodies, nonprofits, federally recognized tribes, and academic institutions. It is strictly for rural areas and towns with population of 10,000 or less. Special consideration may be given for projects serving an area with fewer than 5,500 or fewer than 2,500 people and lower-income populations. This grant can be used to evaluate current landfill conditions to identify threats to water resources, provide technical assistance or training to enhance the operation and

[141] *U.S. Environmental Protection Agency. (2024). Project and Landfill Data by State. EPA - Landfill Methane Outreach Program (LMOP). https://www.epa.gov/lmop/project-and-landfill-data-state*

[142] *U.S. Environmental Protection Agency. (2025, March). Solid Waste Infrastructure for Recycling Grant Program. https://www.epa.gov/infrastructure/solid-waste-infrastructure-recycling-grant-program*

maintenance of active landfills as well as help communities reduce the amount of solid waste coming into a landfill, and help prepare for closure and future use of a landfill site.[143]

4.3.7 Sector 6 Natural Working Lands Measures 13 and 14

"Natural and working lands" (NWLs) refer to agricultural lands, natural and or plantation forests, coastal habitats, floodplains and wetlands, urban trees and green spaces, and all other ecosystems and working lands that provide ecosystem services including carbon sequestration. NWLs may be managed to support food or timber production for human communities (as in the case of working forests, cropland, and pastureland) or managed primarily for their ecosystem services (as in the case of wetlands, salt marsh, parks, and non-timbered forests.) This definition also includes natural and working waters including rivers, lakes, estuaries, and coastal waters (NWL Action Plan 2020).[144]

Where the other sectors in this CCAP are *sources* of greenhouse gas emissions that need to be reduced, the NWL sector *sequesters and stores* GHGs and thereby provide an important component to reaching a *net-zero* target. Conservation of NWLs also leads to avoided emissions. At the same time, NWLs provide a range of additional, free ecosystem services such as wildlife habitat, improved water, improved air quality, recreational value, and more. According to the state's most recent inventory, activity on forestland and agricultural lands resulted in a net sequestration of approximately 48 $MMTCO_2e$ in North Carolina. The NWL sector "netted out" 34% of the state's gross GHG emissions for 2020.

This section describes projects that are planned to be completed between 2025-2030 using funding from the Atlantic Conservation Coalition (ACC) established in 2024 through a $421 million grant to North Carolina, South Carolina, Virginia, and Maryland. Table 35 shows projected GHG sequestration. The

NWL Key Take Aways

NCDNCR has developed and modeled two measures for the NWL sector that collectively will offset GHG emissions by 7.1% by 2030 and 59.3% by 2050. These include:

Implementing coastal habitat and peatland restoration projects will result in sequestration of 2,340,539 $MTCO_2e$ in 2030 and 19,215,883 $MTCO_2e$ in 2050. Restoration projects will also protect two national seashores from erosion and SLR, bolster flood resilience, enhance water quality and support local communities.

Encouraging the protection, use, and restoration of agricultural and forested land and promote sustainable forestry management practices. This initiative is expected to yield 10,000 acres of climate-smart forestry and soil health practices implemented between 2025 and 2030, resulting in carbon sequestration of 1,021,710 $MTCO_2e$ in 2030 and 8,811,295 $MTCO_2e$ in 2050.

[143] *U.S. Department of Agriculture. (2022, December 6). Solid waste management grants in North Carolina. Rural Development. https://www.rd.usda.gov/programs-services/water-environmental-programs/solid-waste-management-grants/nc*

[144] *North Carolina Department of Environmental Quality. (n.d.). Natural and Working Lands Action Plan. North Carolina Department of Environmental Quality. https://www.deq.nc.gov/environmental-assistance-and-customer-service/climate-change/natural-working-lands/nwl-action-plan-final-copy/download*

ACC will fund conservation and restoration projects on natural and working lands, community outreach, and research to ensure projects' carbon storage and sequestration benefits are realized. The ACC-funded projects detailed below are by no means comprehensive of all NWL needs in North Carolina. Rather, they were the highest-priority NWL projects identified by a wide coalition of North Carolina stakeholders through an ongoing process that started with 2020 NWL Action Plan development.

All projects detailed below are at the initiation stages or are yet to begin at the time of writing. Progress on projects will be updated in late 2025 on a public dashboard created by Duke's Nicholas Institute for Energy, Environment, and Sustainability.[145]

The measures contained in this section are divided into 13 - Coastal Conservation and Restoration and 14 - Protect, Use, and Develop Agricultural and Forest Land. Additional background information can be found in Appendix B.

Table 36. Total GHG emissions offset in $MTCO_2e$ that can be implemented through Measures 13 and 14

Measure Number-Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
13 - Coastal Habitat Enhancement and Peatlands Restoration	2,340,539.4	19,215,883.2
14 - Protect, Use, and Develop Agricultural and Forest Land	1,021,710.0	8,811,294.8
Total	**3,362,249.4**	**28,027,178**

Implementation Authority and Responsibilities for all Natural and Working Lands Projects and Initiatives

See Figure 8 15 Implementation Authority and Lead Agencies

Measure 13. Coastal Habitat Enhancement and Peatlands Restoration

The measure aims to provide ways in which to implement coastal habitat restoration and peatland restoration projects. Example projects funded by North Carolina's portion of the ACC grant are detailed below. In addition to protecting and restoring these natural carbon sinks and sequestering GHG emissions, these projects will help to protect two National Seashores from erosion and sea level rise, bolster flood resilience, enhance water quality, and support the traditional economies of local communities.

Measure 13-1. Coastal Habitat Enhancement Initiative

This initiative, led by the North Carolina Coastal Federation, aims to preserve and restore a minimum of 595 acres of coastal habitats and 15 acres of peatlands in North Carolina.[146]

[145] *ACC public dashboard.* http://go.microsoft.com/fwlink/p/?LinkId=255141

[146] *North Carolina Coastal Federation. (n.d.). Coastal Resiliency Initiative. North Carolina Coastal Federation. https://www.nccoast.org/resource/coastal-resiliency-initiative/*

At least six coastal marsh resilience projects are identified for preliminary review, including living shoreline cost-share projects for fringing shoreline marshes, marshes associated with dredge spoil islands in Bogue Sound along the Intracoastal Waterway, sound-side marshes at Cape Lookout and Cape Hatteras National Seashores, marshes on the south side of Roanoke Island in Dare County, and marsh protection and enhancement in the vicinity of Outfall Canal in Hyde County.

The shoreline changes and carbon assessment analysis conducted by NATRX[147] will further evaluate these sites to ensure they meet carbon sequestration benchmarks and identify the most cost-effective locations, and this analysis may identify better alternative project sites that will achieve greater returns on investment in terms of project goals.

Coastal habitat projects are not likely to require any new land acquisition as they will be sited on publicly owned marshes, National Seashores, or private marshes with donated protective easements. Some additional land acquisition may be required to obtain adjoining lands to achieve the peatland restoration goals will occur on a 787-acre property that is currently being purchased by NCCF with funding from the N.C. Land and Water Fund,[148] the Mountain to Sea Trail grant,[149] and the U.S. Navy. This property that is currently being purchased will be protected in perpetuity through conservation easements held by the Navy and the State of North Carolina. If additional land acquisition is necessary, it will be purchase from a willing seller at fair market values as established following the acquisition and due diligence procedures set out by the N.C. Land and Water Fund and the U.S. Navy.

Metrics for Tracking Progress

This initiative is expected to yield 15 acres of peatlands and 595 acres of coastal habitats, newly preserved and restored. Other potential output-based measures include linear feet of living shoreline constructed and volume of sediment added to vulnerable marshes to prevent their drowning due to sea level rise.

Implementation Timelines and Milestones

- Location identification, project prioritization, and feasibility studies for habitat projects. (Y1-Y2) (Assumes coordination with partners to scope out, plan, and design projects.)
- Permitting of habitat projects. (Y1Q1-Q3) (Assumes authorizations when project designs developed.)
- Develop subcontracts for research (US Geological Survey and Site Analysis with Natrx). (Y1Q1-Q3)
- Project construction. (Y1Q4-Y5) (Assumes projects phased into construction phases, some are ready.)
- Baseline and post-project monitoring. (Y1Q3-Y5) (Assumes research team begins work in Y1Q3.)

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[147] *Natrx • Adaptive Infrastructure - Natrx Adaptive Infrastructure. https://natrx.io/*

[148] *North Carolina Land and Water Fund. (n.d.). Home. North Carolina Land and Water Fund. https://nclwf.nc.gov/*

[149] *North Carolina Department of Natural and Cultural Resources. (2024, November 21). State trails projects receive over $6.6 million in grants. North Carolina Department of Natural and Cultural Resources. https://www.dncr.nc.gov/news/press-releases/2024/11/21/state-trails-projects-receive-over-66-million-grants*

- Community engagement. (Y1Q4-Y4) (Assumes community outreach centered on project sites.)
- Communications (Coastal Review online series on carbon, TV news stories on projects produced by the NC Coastal Federation (NCCF) in partnership with various TV stations). (Y1-Y5, quarterly)

Measure Costs

The total coastal habitat enhancement projects outlined above, completed as part of the ACC grant, will cost approximately $68.5/MTCO$_2$e. Costs per acre ranges are noted below (Table 36).

Table 37. Total Costs for Measure 13-1 Coastal Habitat Enhancement Initiative

Project type	Description	Cost per acre range	Cost notes/assumptions
Living shorelines	Living shoreline structures to enhance longevity of vulnerable marsh	$38,000 - $55,000	Based on specific projects identified by ACC members.
Peatland restoration	Hydrologic restoration of peatlands	$2,000-$4,000	Cost includes land acquisition (if needed) and restoration, based on ACC members' previous experience. These costs vary for specific projects depending on land ownership, use, and type of water control structures.
Promoting marsh migration	Conservation of land in marsh migration corridors to ensure it is available for migration with SLR.	$3,000-$20,000	Based on specific projects identified by ACC members. Low end is for developing management plans for privately owned property (distributed); high end is for acquiring/preserving land directly.
Coastal marsh restoration	Marsh restoration includes a variety of practices including hydrologic restoration, placement of a thin layer of sediment to	$10,000 - $45,000	Based on specific projects identified by ACC members. Cost varies greatly depending on restoration practice.

	elevate marsh, and planting.		

Intersection with Other Funding Availability

NCCF and its partners are carrying out the projects outlined above using ACC grant funding. They complete similar projects across North Carolina's coast with funding from an extensive range of state, federal, and foundation grants; legislative pilot funding; and donations from members.

Measure 13-2. Peatland Restoration on Public Land and Acquisition & Restoration on Private Land

This project will protect and restore peatland pocosin wetlands on both public and private land. This initiative, led by The Nature Conservancy (TNC), aims to preserve and restore approximately 33,000 acres of peatland pocosins in North Carolina and to restore their ecosystem function where necessary. Eastern North Carolina and southeastern Virginia are home to the greatest concentration of peat-based pocosin, wetland landscapes in the U.S. Hydrologic restoration to rewet the peat soil has proven effective at reducing emissions and increasing sequestration.[150] TNC's restoration process includes:

- Design, establishment, and maintenance of a hydrologic monitoring network
- Collection and analysis of field data
- Development of engineered restoration design
- Installation of restoration interventions
- Evaluation and refinement of hydrology post-restoration
- Ensuring adequate management staff capacity and financial resources to sustain long-term restoration integrity and realization of project GHG benefits

Specific outcomes may vary based on landowner outreach but are expected to include a mix of restoration on large, publicly owned tracts of land, and conservation/restoration on smaller, privately-owned properties that TNC purchases or establishes conservation easements on with landowners and then restores. TNC will work with carbon consultants, hydrologic restoration consultants, and contractors who will place water control structures.

Metrics for Tracking Progress

This project aims to preserve and restore 33,000 acres of peatland pocosins. Other output-based metrics could include number of land transactions and conservation easements established with private landowners. Likely outcome-based metrics include pre- vs. post-restoration hydrology of peatlands that are restored.

Implementation Timelines and Milestones

[150] *The Nature Conservancy. (n.d.). North Carolina peatlands. The Nature Conservancy. https://www.nature.org/en-us/about-us/where-we-work/united-states/north-carolina/stories-in-north-carolina/north-carolina-peatlands/*

- GIS analysis, utilizing carbon assessment outputs, conducted to prioritize private landowners for acquisition outreach. (Y1Q1-Y1Q2)
- Hydrologic assessment and modeling of benefits for restorable pocosins on public lands. (Y1Q2)
- Hiring project staff including project manager, acquisition, and restoration specialists. (Y1Q3)
- Assemble Year 1 cohort of priority properties, conduct landowner outreach. (Y1Q3-Q4)
- Assessments of properties including appraisals, titles, ecological conditions, etc. (Y2Q1-Y5Q1) (Assumes outreach yields landowners interested in conservation and restoration.)
- Acquire interest in properties by fee easement or long-term agreement sufficient to ensure restoration implementation, management, and carbon permanence. (Y2Q4-Y5Q2) (Assumes valuations and details compel ownerships to conservation management.)
- Contract for design/permitting/implementation of hydrologic restoration to rewet peat. (Y2Q1-Y5Q3)
- Monitor implementation results and assess carbon sequestration.

Measure Costs

The measure cost is based on an average using a range of property acquisition tools that include fee, easement, and 25 year lease/rental to secure hydrologic restoration, management, and monitoring rights.

Table 38. Total Costs for Measure 13-2. Peatland Restoration on Public Land and Acquisition & Restoration on Private Land

Project	Cost per acre (average)	Cost notes/assumptions
Hydrologic restoration of peatlands	$2,057.26	Cost based on an average using a range of property acquisition tools that include fee, easement, and 25 year lease/rental to secure hydrologic restoration, management, and monitoring rights.

Intersection with Other Funding Availability

TNC will complete the peatland restoration work outlined above using ACC funding. They have an extensive track record of peatland restoration work in North Carolina and adjoining states using ACC funds as well as other state, federal, and foundation grants. Recent grants relevant to TNC's peatland restoration work in North Carolina include two NFWF Emergency Coastal Resilience Fund grants awarded, and two North Carolina Land and Water Fund Restoration Program grants awarded.

Measure 13. Quantified GHG Emission Reduction or Enhancement of Carbon Sinks

The GHG benefits from coastal habitat and peatlands are estimated based on proposed project area and per-acre GHG benefits obtained from scientific literature (Table 38). Implementation assumptions vary by geography and project type, with a primary assumption that projects will stay within budget. Refer to Appendix E for more detail on methods.

Table 39. Measure 13 GHG Emission Offsets (MTCO2e)

Measure Number-Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
13 - Coastal Habitat Enhancement and Peatlands Restoration	2,340,539.4	19,215,883.2

Measure 14. Protect, use, and develop agricultural and forest land

This measure covers the protection, use, and restoration of agricultural and forested land and promotes sustainable forestry management practices to increase carbon sequestration.

Measure 14-1. Climate Smart Forestry in Low-income and Rural Communities

This initiative, led by the Roanoke Cooperative through their Sustainable Forestry and Land Retention Project (SFLRP), will support small forest landowners in implementing climate-smart practices, reforestation, and conservation easements. Roanoke Cooperative currently works to promote sustainable forestry and land retention in thirteen counties in northeastern North Carolina (Bertie, Chowan, Edgecombe, Gates, Granville, Halifax, Hertford, Martin, Nash, Northampton, Perquimans, Vance, and Warren). Funding from this project may also allow SFLRP to assist forest landowners in central and southeast central North Carolina in the following counties: Bladen, Columbus, Duplin, Franklin, Greene, Harnett, Hoke, Jones, Onslow, New Hanover, Pender, Pitt, Robeson, Sampson, Washington, Wayne, and Wilson. Roanoke Cooperative has strong and long-lasting partnerships with the North Carolina Forest Service, USDA, county soil and water districts, conservation organizations, and non-profit organizations. They also collaborate extensively with community-based organizations, which positions them to conduct grassroots outreach and landowner education.[151]

A vital component of the services provided by SFLRP is increasing awareness and implementing climate-smart forestry, improving soil health, addressing heirs' property strategies, and navigating the complex process of conservation easements to landowners through outreach strategies.

Conservation easements are an essential tool to make land conservation legally permanent; this project will help low-income rural residents with funding and technical assistance to develop conservation easements on their properties. This will ensure that land conservation

[151] *Roanoke Cooperative. (n.d.). Roanoke Sustainable Forestry. Roanoke Cooperative. https://www.roanokecooperative.com/roanoke-sustainable-forestry/*

and associated GHG benefits continue in perpetuity. The reforestation and climate-smart forest management components of this project contribute to net decreases in GHG emissions.

Outreach strategies will include, but are not limited to, webinars, community workshops, annual forest landowner conferences, and one-on-one sessions with individual family farm and forest owners. Recognizing that not everyone in rural communities has broadband access, outreach will be conducted through all social media and digital platforms, radio, fact sheets and other publications, as well as local newspapers to inform the public about SFLRP and all available technical and financial resources.

Metrics for Tracking Progress

This initiative is expected to yield 10,000 acres of climate-smart forestry and soil health practices implemented between 2025 and 2030. It will also involve developing a $500,000 cost share program to implement climate-smart practices for forestry, soil health, and carbon sequestration.

Additional output-based metrics include:

- Outreach to ~2,500 low-income, rural landowners per year on climate-smart forestry, soil health, and conservation easements, including via:
- An annual conference
- 4-6 workshops per year
- Data collection
- Landowner surveys to determine awareness of natural resource agency technical and financial assistance, behavioral changes
- Pre- and post-intervention surveys to determine knowledge increase

Implementation Timelines and Milestones

1. The Roanoke Cooperative's SFLRP will develop strategies to address climate-smart forestry practices. (Y1Q1)
2. Develop cost-share program framework. (Y1Q2)
3. Landowner outreach and implementation of cost-share program. (Y1-Y5) (Assumes adequate landowners willing to participate. Robust community outreach will take place.)

Measure Costs

The cost for this measure include a variety of tree planting to support reforestation.

Table 40. Total Cost for Measure 14-1 Climate Smart Forestry in Low-income and Rural Communities

Project type	Cost per acre	Cost notes/assumptions
Reforestation	$500	The majority of the tree planting will be conifer species (e.g., Loblolly, Longleaf, Shortleaf, cypress). Additionally, a variety of hardwood species may be planted (e.g., oaks, yellow poplar, black gum, ash). In some cases, for wildlife habitat, hickory, dogwood, redbud, and black walnut will be planted.

Intersection with Other Funding Availability (Awarded)

- US Forest Service[152]
- Laughing Gull Foundation[153]
- Southern Bank[154]
- CoBank[155]
- NC Electric Membership Corporation[156]
- US Endowment for Forestry and Communities[157]

Measure 14-2. Rapid Tree Growth High-Carbon Forestry - Cost Share

This cost share program would incentivize planting tree seedlings with genetics that enable increased carbon sequestration and implementing silvicultural practices that likewise increase the rate of carbon sequestration.

Cost-share funds will be available statewide, although most funded projects are expected to occur within North Carlina's Coastal Plain and Piedmont regions. The forestry cost-share program will be modeled after the existing NC Forest Development Program;[158] however, the new program will be unique and will be administered independently. Program development will involve:

- Creating and filling a new forestry cost-share administrator position

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[152] *U.S. Forest Service. (n.d.). About the agency. U.S. Department of Agriculture. https://www.fs.usda.gov/about-agency*
[153] *Laughing Gull Foundation. (n.d.). About us. Laughing Gull Foundation. https://laughinggull.org/about-us/*
[154] *Southern Bank. (n.d.). About us. Southern Bank. https://www.southernbank.com/about/*
[155] *CoBank. (n.d.). Home. CoBank. https://www.cobank.com/*
[156] *North Carolina Electric Cooperatives. (n.d.). Who we are. North Carolina Electric Cooperatives. https://www.ncelectriccooperatives.com/who-we-are/*
[157] *U.S. Endowment for Forestry and Communities. (n.d.). Home. U.S. Endowment for Forestry and Communities. https://www.usendowment.org/*
[158] *North Carolina Forest Service. (n.d.). Forest Development Program (FDP). North Carolina Department of Agriculture and Consumer Services. https://www.ncagr.gov/divisions/nc-forest-service/managing-your-forest/fdp*

- Developing a cost-share application form and procedures to accept applications
- Developing forestry practice written plan criteria
- Developing a database to administer the program, such as tracking applications, practice data, financial data, and reporting/accomplishment data
- Determining which practices and sub-practices will be eligible
- Establishing criteria and standards for each eligible forestry practice
- Developing a program handbook to provide guidelines on administering the program at both the NCFS field level and agency headquarters level
- Establishing cost-share percentage rates and prevailing ($) rates for each practice and sub-practice per geographic region of the state
- Establishing applicant ownership criteria and acreage limits (minimum & maximum)
- Establishing performance maintenance period and penalties
- Establishing funding allocation procedures and timelines (e.g., random draw vs first come, first served)
- Establishing landowner payment procedures and required documents
- Developing annual program budgets

Metrics for Tracking Progress

Quantitative outcomes and outputs will include:

- Acres of forestry practices completed by practice, county, and forest type/species
- Number of landowners receiving financial assistance
- Cost-share amounts paid and total practice cost per landowner contract, practice, county, and forest type/species
- Number of tree seedlings planted by county, and forest type/species
- Qualitative and quantitative program impacts benefiting low-income landowners/areas

Implementation Timelines and Milestones

- Program development. (Y1)
- Community outreach and promotion. (Y1-Y5)
- Cost-share database modifications to allow for new program. (Y1-Y2)
- Program begins accepting applications. (Y1) (Assumes program can be quickly started due to existing forest development program model and experienced staff.)
- Program applications accepted and awarded. (Y1-Y5)
- Project implementation. (Y1-Y5)
- Annual reporting. (Y1-Y5)
- Program close-out and final review and reporting. (Y5)

Measure Costs

Cost based on average Forest Development Program (FDP) cost share paid per acre for containerized loblolly pine hand planting

Table 41. Total Costs for Measure 14-2 Rapid Tree Growth High-Carbon Forestry – Cost Share

Project type	Cost per acre	Cost notes/assumptions
Reforestation	$101	Cost based on average Forest Development Program (FDP) cost share paid per acre for containerized loblolly pine hand planting ($60.17) in 2022-2023, plus 75% of the average cost share paid per acre for the three most common site prep activities (chemical control, K-G V-blade shear, and bedding) ($53.88 * 0.75 = $40.41) in 2022-2023, reflecting the assumption that 75% of loblolly planting requests also include site prep.

Intersection with Other Funding Availability

This cost-share program is modeled after NCFS' long-standing Forest Development Program, which is funded by state appropriations and assessments on primary forest products. There is consistently more demand for cost-share funding than supply, but state appropriations have helped offset demand somewhat.

Measure 14-3. Urban Tree Planting Program

The urban tree planting cost share program will offer funding assistance for municipalities and nonprofits to complete urban tree planting projects in their jurisdictions that include developing a tree planting plan, tree supply and planting, and two years of maintenance. This program is managed by the NC Forest Service (NCFS). Priority will also be given to small and medium-sized communities that have the highest need for urban and community forestry, as based on the community's NCFS management classification[159] (see Financial Assistance Program webpage), a blend of the USDA Forest Service Urban & Community Forestry Community Accomplishment Reporting measures and Arbor Day Foundation Tree City USA measures. Approximately 1,200 2 ½ inch caliper trees will be planted and maintained.

Metrics for Tracking Progress

The funding will result in planting of approximately 1,200 new trees.

Quantitative outputs and outcomes will include:

- Number of trees planted
- Number of projects awarded

[159] *Move hyperlinks to footnote*

- Number of communities served

Implementation Timelines and Milestones

- Program development. (Y1Q1-Q2) (Assumes grant is awarded and funding is allocated.)
- Program outreach and promotion. (Y1-Y5)
- Request for applications. (Y1Q3, Y2Q2-Y5Q2)
- Project awards announced. (Y1Q3, Y2Q2-Y5Q2)
- Project implementation and close-out. (Y1Q4-Y5)

Measure Costs

Table 42. Total Costs for Measure 14-3 Urban Tree Planting Program

Project type	Cost per tree	Cost notes/assumptions
Urban tree planting	$800	Cost per tree from NCFS Urban and Community Forestry manager

Intersection with Other Funding Availability

This program is modeled after NCFS' existing Urban and Community Forestry Financial Assistance Program, which is funded by a range of federal grants.[160]

Measure 14-4. High-Carbon Acquisitions for North Carolina State Park System

This project involves identifying and purchasing privately-owned land from willing landowners to add to the state park system. Land adjacent to existing parks with the highest potential carbon value and threat of land use conversion will be prioritized. Many of these lands are peatlands or other coastal plain wetlands. This project is expected to lead to restoration of degraded peatlands within purchased land tracts. If the State cannot purchase these high-carbon areas, this land will likely no longer sequester carbon in the future. Acquiring this land into the North Carlina State Park System will protect it from conversion in perpetuity.

The North Carlina State Parks System Planning/Land Acquisition team identified about 20+ sites totaling over 45,000 acres that are adjacent to state parks, are priority tracts for acquisition, and meet the criteria for carbon sequestration. The prioritization of tracts to pursue first will be determined by a further analysis of the original list in terms of carbon sequestration value and the willingness of landowners to sell.

[160] *North Carolina Forest Service. (n.d.). Urban and Community Forestry Financial Assistance Program. North Carolina Department of Agriculture and Consumer Services. https://www.ncagr.gov/divisions/nc-forest-service/urban/financial-assistance-program*

Metrics for Tracking Progress

3,300 acres will be permanently added to State Park System. Intermediate metrics could include status/achievement of the following steps of restoration:

- Design, establish, and maintain a hydrologic monitoring network
- Collection and analysis of field data
- Develop engineered restoration design
- Installation of restoration interventions
- Evaluation and refinement of post-restoration hydrologic
- Ensure adequate management staff capacity and financial resources to sustain long term restoration integrity and realization of project GHG benefits

Implementation Timelines and Milestones

1. Duke University, in partnership with NCDNCR, is currently identifying tracts for potential acquisition by NC State Parks with high expected carbon benefits. (Y1Q1-Q2)
    a. "Future needs" tracts that have been previously identified by NC State Parks as ecologically desirable and spatially contiguous to existing state parks will provide a starting point for this analysis.
    b. The expected carbon value of acquiring tracts around existing state parks will be assessed based on each tract's vulnerability to land conversion and its carbon stock relative to nearby land with similar likelihood of conversion. This relative carbon stock approach accounts for the potential for land conversion to "leak" from acquired land to nearby land; focusing on tracts with high carbon stocks relative to the local landscape ensures that the acquisition will have a carbon benefit even if some leakage occurs.
    c. A subset of tracts also has potential for additional carbon benefits through peatland restoration or eliminating timber harvest after they are acquired by NC State Parks. These carbon benefits will be quantified for each tract based on the methods described in the CPRG technical appendix for peatland restoration and IFM projects, respectively.
    d. Tracts will be classified into priority categories based on their total expected carbon benefits, so that NCDNCR can begin acquisition conversations with landowners of tracts in the highest priority category.

2. NCDNCR begins conversations with landowners in the highest ranked tracts for acquisition. (Y1Q3)

3. NCDNCR begins acquisition process, integrating high-priority tract(s) into the state park system. (Y2-Y5) (Assumes landowners are willing to sell land. If not, NCDNCR will shift to pre-ranked alternatives.)

Measure Costs

Table 43. Total Costs for Measure 14-4 High-Carbon Acquisitions for NC State Park System

Project	Cost per acre (average)	Cost notes/assumptions
Improved forest management and avoided conversion of existing forest	$3,000	Cost estimate from Brian Strong, North Carolina State Park system Director

Intersection with Other Funding Availability

The North Carolina State Parks system will complete this work using ACC grant funds. The State Parks system has ample funding to purchase land and award grants through the Parks and Recreation Trust Fund.

Measure 14. Quantified GHG Emission Reduction or Enhancement of Carbon Sinks

GHG benefits from forestry projects are categorized into improved forest management, reforestation, urban tree planting, and avoided forest conversion, Table 43. Per-acre estimates for GHG benefits are calculated using various data models and methodologies specific to each project type. The primary activity data used to track progress across project types include acres conserved, acres reforested, and number of trees planted. Refer to Appendix E for more detail on methods.

Table 44. Measure 14 GHG Emission Offests (MTCO2e)

Measure Number-Title	2030 ($MTCO_2e$)	2050 ($MTCO_2e$)
14 - Protect, use, and develop agricultural and forest land	1,021,710.0	8,811,294.8

4.3.8 Municipal Highlights

Many cities and counties in North Carlina have been developing Climate Action Plans in the last few years. Highlighted here are plans from Asheville (Figure 15), Boone (Figure 16), Greensboro (Figure 17), and Wilmington (Figure) to provide frameworks that local jurisdictions may choose to emulate. New Hanover County is also included as it will publish a plan later in 2025 (Figure).

All the plans include GHG reduction targets by 2030 or later through implementing strategies across electricity, buildings, transportation, natural landscapes, and waste management sectors to achieve their goals.

The plans also highlight ways in which these local governments can become more resilient against extreme weather events and electric grid disruptions.

Emission reductions from these plans are not captured in the NCDEQ CCAP because double-counting may be inadvertently introduced.

Figure 16. City of Asheville Climate Action Plan

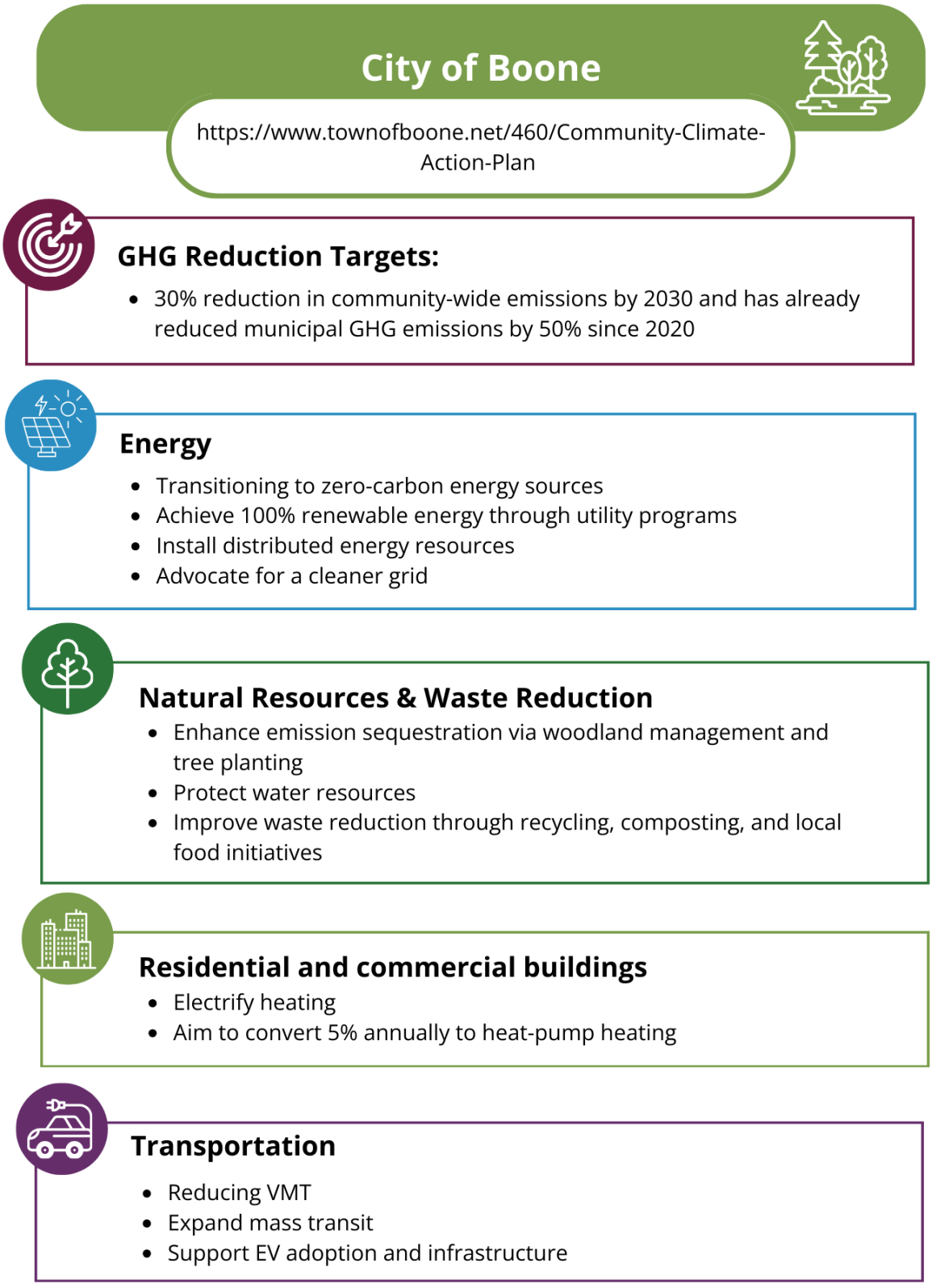

Figure 17. City of Boone Climate Action Plan

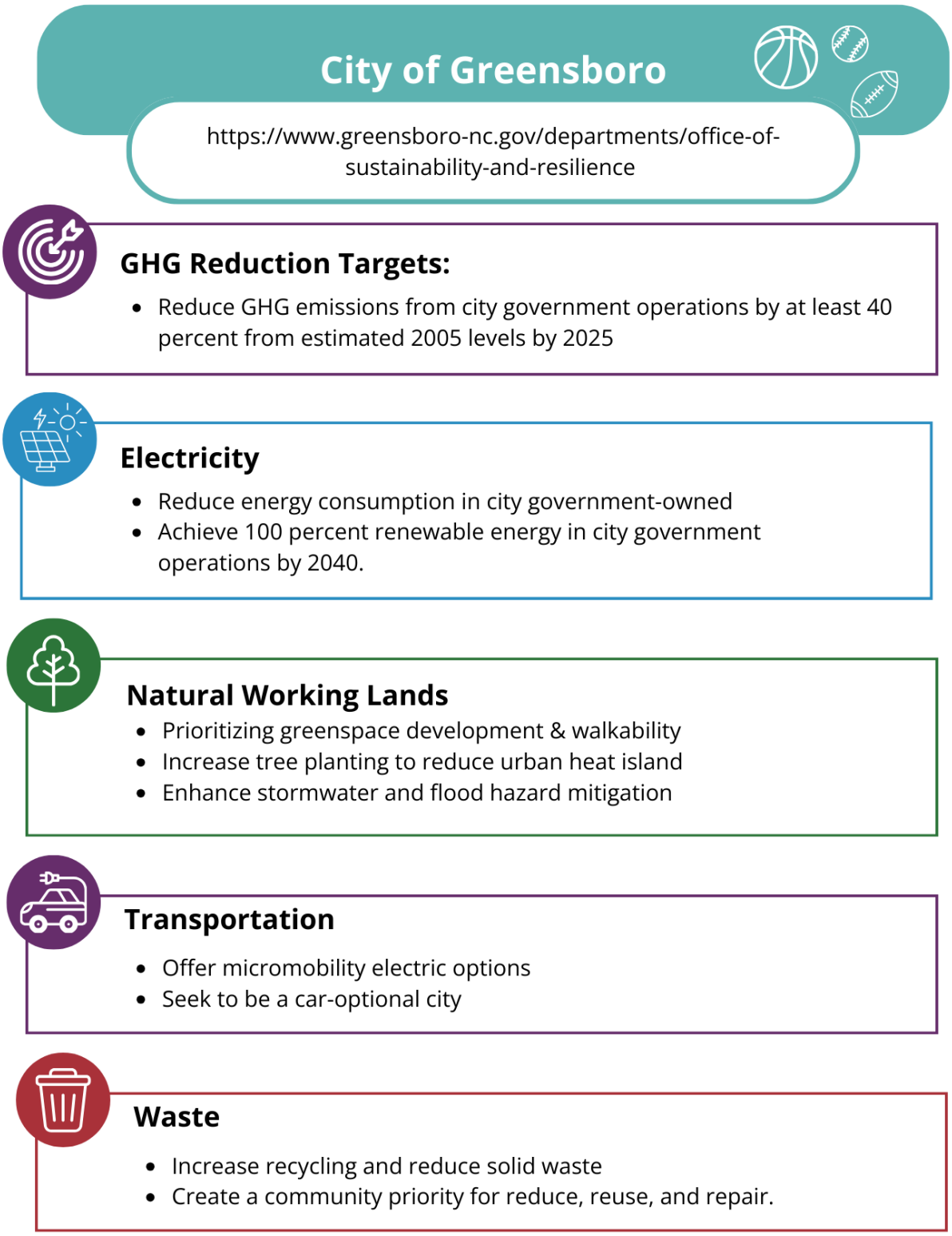

Figure 18. City of Greensboro Climate Action Plan

Figure 19. City of Wilmington Climate Action Plan

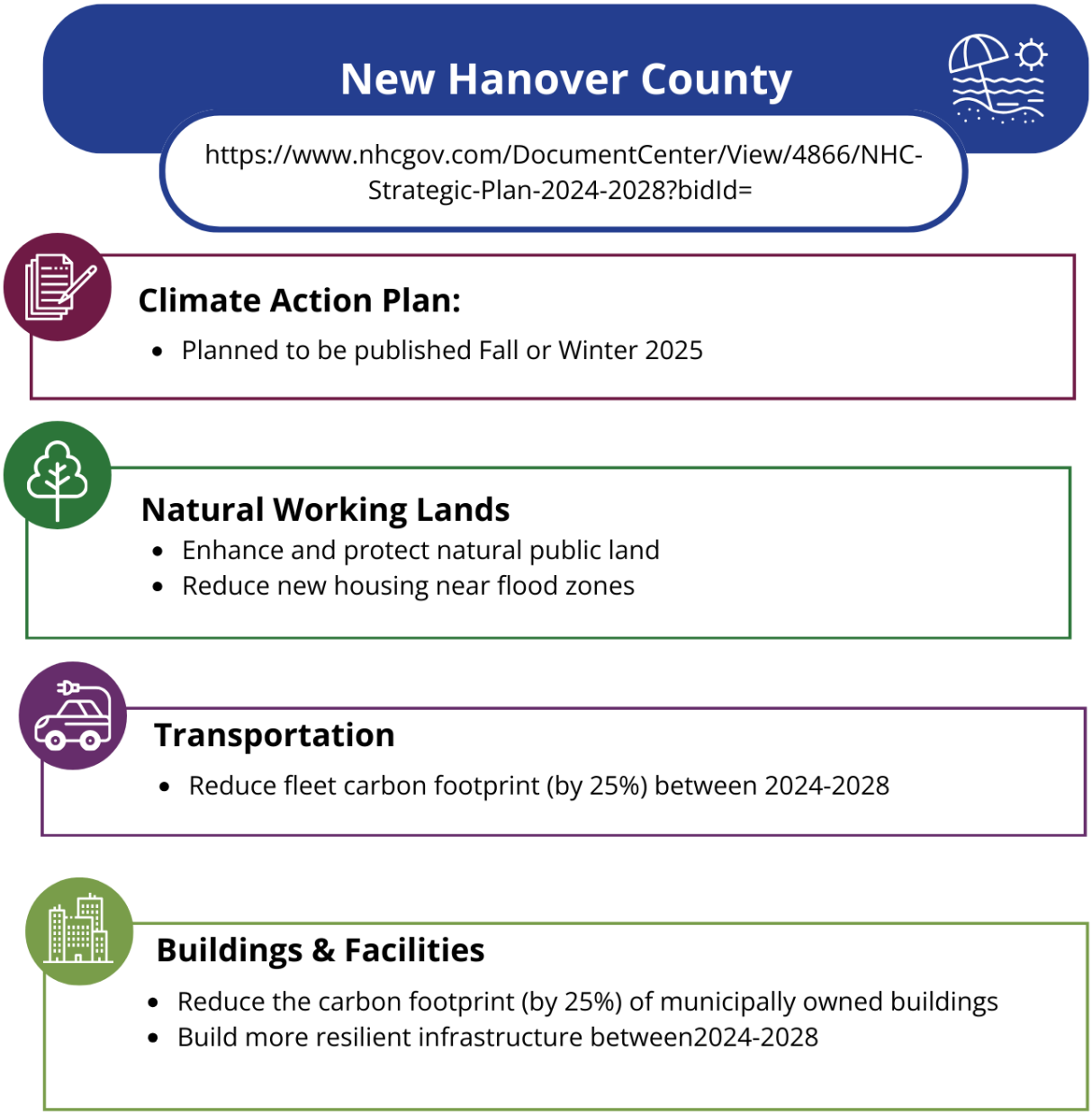

Figure 20. New Hanover County Climate Action Plan

5 Benefits Analysis

5.1 Co-pollutant Analysis

NCDEQ developed the benefits analysis of co-pollutant reductions (e.g., $PM_{2.5}$, NO_X, SO_2, VOCs, air toxics, etc.) associated with the proposed suite of GHG reduction measures. The analysis was derived using data from EPA's Emission Modeling Platform for 2022v1[161] which includes analytic/projections for years 2026, 2032, and 2038 for North Caolina. The co-pollutant reductions are presented at a sector level only and not aligned directly to each measure except by sector. Additionally, the co-pollutant reductions represent a state-wide analysis. The co-pollutant reductions are shown in Table 44 below:

Table 45. Co-pollutant reduction projections for 2026, 2032, and 2038 by sector in tons per year (tpy)

Sector	2026					2032					2038				
	NOX	VOC	PM2.5	NH3	SO2	NOX	VOC	PM2.5	NH3	SO2	NOX	VOC	PM2.5	NH3	SO2
Electricity Generation	5,383	431	710	137	351	4,579	521	981	166	316	4,251	530	926	159	280
Commercial and Residential Buildings	9,868	11,142	16,048	1,221	428	9,817	11,232	16,612	1,211	430	9,749	11,318	17,171	1,205	428
Transportation	77,334	53,591	22,170	6,378	1,022	52,522	48,485	22,160	5,600	1,022	46,381	45,900	22,444	4,494	995
Agriculture	0	16,193	8,987	232,190	0	0	16,693	9,130	238,439	0	0	17,193	9,180	244,687	0
Waste and Materials Management	1,708	3,814	8,196	1,863	463	1,730	3,927	8,208	1,928	480	1,759	4,049	8,223	1,992	500
Industry	23,509	143,116	10,226	1,209	9,107	23,721	147,008	10,383	1,229	9,082	24,273	153,519	10,693	1,258	9,112
Natural and Working Lands	24,438	1,148,684	12,351	753	1,042	24,438	1,148,684	12,351	753	1,042	24,438	1,148,684	12,351	753	1,042
Total	**142,240**	**1,376,972**	**78,687**	**243,752**	**12,411**	**116,806**	**1,376,551**	**79,824**	**249,327**	**12,370**	**110,852**	**1,381,194**	**80,988**	**254,549**	**12,357**

Overarchingly, emission reductions are observed across all sectors for all co-pollutants. A comparison between the highest pollutant emission by sector and the total for that pollutant indicated pollutant drivers for each sector. Notably, the transportation sector accounts for the highest NO_X (54%) and $PM_{2.5}$ emissions (28%), while the industrial sector accounts for the highest SO_2 emissions (73%). The natural working lands sector accounts for the highest VOC emissions (83%) which is not surprising given the number of pine trees in NC which emit isoprene, a VOC. The agricultural sector accounts for the highest NH_3 emissions (96%) which is also not surprising given that fertilizers and bean crops contain NH_3. This analysis is shown in Table 45 below:

[161] *EPA's Emission Modeling Platform for 2022v1.* https://www.epa.gov/air-emissions-modeling/2022v1-emissions-modeling-platform

Table 46. Co-pollutant driver per sector (%)

Sector	2026					2032					2038				
	NOX	VOC	PM2.5	NH3	SO2	NOX	VOC	PM2.5	NH3	SO2	NOX	VOC	PM2.5	NH3	SO2
Transportation	54%		28%			45%		28%			42%		28%		
NWL		83%					83%					83%			
Agriculture				95%					96%					96%	
Industry					73%					73%					74%

5.2 Health Benefits

One of the biggest benefits of reducing GHG emissions is the reduction of co-pollutants. Thes reductions can result in improved health outcomes because of decreased exposure to NO_X, a component in ground-level ozone[162] and $PM_{2.5.}$[163] Exposure to ozone especially effects people with respiratory illnesses like asthma; however, at high levels even healthy people can experience coughing, inflamed airways, or trouble breathing[164]. Exposure to $PM_{2.5}$ can affect both the lungs and the heart especially for those people who have respiratory or cardiovascular illnesses.[165] $PM_{2.5}$ are the main cause of reduced visibility (haze) in parts of the United States, and especially in western NC. Notably, $PM_{2.5}$ is also a main result from wildfires therefore, any additional reduction in extreme weather events, like wildfires, is a benefit on many fronts.

Additional benefits for this measure are decreases in SO_2 emissions which account for 73% of the total emissions. Short-term exposure to SO_2 can harm the human respiratory system and make breathing difficult. People with asthma, particularly children, are sensitive to these effects of SO_2. SO_2 contributes to acid rain and can harm trees and plants by damaging foliage and decreasing growth. Additionally, SO_2 can react with other compounds in the atmosphere to form fine particles that reduce visibility (haze).[166]

5.3 Economic and Workforce Benefits

Reducing GHG emissions provides many economic and workforce benefits across the state. Across the transportation, electricity and building sectors are opportunities for residents to save money from converting from an internal combustion engine car to an electric vehicle, using solar power, and improving their homesteads by weatherizing and purchasing electric equipment. Many of these options are available at reduced or rebated costs to the consumer, which also saves money.

Notably, clean energy jobs for workers are in high demand and are anticipated to continue especially those for the wind, solar, electric vehicle construction and repair and building efficiency (construction) sectors. The NC Department of Commerce estimated that an additional 10,000 jobs could be created by 2050 to support the clean energy economy (Section

[162] https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics
[163] https://www.epa.gov/pm-pollution/particulate-matter-pm-basics
[164] https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution
[165] https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm
[166] https://www.epa.gov/so2-pollution/sulfur-dioxide-basics#effects

7). Additionally, occupations like computer technology, sales, administration, management, and financial services will be needed to support all sectors.

5.4 Resiliency Benefits

Reducing GHG emissions across all sectors of the economy have benefits to the energy system in NC. The NC Energy Security Plan[167] is a strategic guide to help policy makers in NC plan for and recover from disruptions to the energy system. NC's energy system faces a set of multifaceted challenges that threaten its reliability, affordability, and resilience. Dependence on imported fossil fuels, aging infrastructure, growing energy demand, and vulnerability to natural disasters like hurricanes and floods highlight the urgent need for strategic solutions to secure the state's energy future. The strategies outlined in the plan include elevating/hardening distribution and substation equipment, upgrading transmission systems, diversifying energy sources through utility-scale renewables, integrating technologies such as Battery Energy Storage Systems (BESS) or Long Duration Energy Storage (LDES), debunking misinformation, and deploying microgrids or backup generation at critical facilities. Implementing these strategies will bolster the resilience and reliability of NC's energy system, minimizing the economic and social toll of energy disruptions. By preventing or limiting the length of power outages, businesses avoid costly downtime, and residents maintain access to essential services. Resilient infrastructure will also enhance public safety, ensuring critical facilities like hospitals remain operational during crises, ultimately reducing mortality rates during extreme weather events.

5.5 Natural Working Lands Benefits

Much of the forestland in NC is privately owned and managed. Cost-share programs for reforestation on small family-owned operations are essential to financially support and enable landowners to implement climate-smart practices. Additionally, up to 31% of mapped peatlands may also be privately owned. Conservation and restoration of privately-owned peatlands is essential to maintaining and enhancing these important ecosystems' carbon sequestration capacity. At least 70% of North Carolina's peatlands have been drained, which causes them to become carbon sources rather than carbon sinks and leads to land subsidence.[168] Rewetting hydrologically altered peatlands helps to reduce CO2 emissions from degraded peatlands and helps to prevent soil loss and catastrophic fires that can endanger lives and property and release extensive GHGs. Restoring peatlands already in public ownership helps reduce these risks.

This program will help fund communities to improve their forest canopy coverage. In addition to providing more rapid carbon sequestration, trees planted through this program will provide benefits including wildlife habitat, erosion prevention, better air quality and water quality/runoff infiltration.

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[167] *NC Energy Security Plan. https://www.deq.nc.gov/state-energy-office/2025-draft-nc-energy-security-plan/open?utm_medium=email&utm_source=govdelivery*

[168] *North Carolina Department of Environmental Quality. (n.d.). Natural and Working Lands Action Plan. North Carolina Department of Environmental Quality. https://www.deq.nc.gov/environmental-assistance-and-customer-service/climate-change/natural-working-lands/nwl-action-plan-final-copy/download*

The project will reduce emissions through energy savings in addition to carbon sequestration. Co-benefits include improved shade and green space, reduction in hazardous air pollutants, and improved stormwater management.

New state parklands will provide recreational value, resilience to droughts and stormwater impacts, and wildlife habitat.

5.6 Disbenefits discussion

While most CCAP measures are expected to create benefits, there can be outcomes that may not be beneficial, i.e., "disbenefits." The disbenefits illustrated below are not comprehensive, rather they are examples only.

5.6.1 Transportation

Many of the projects identified in Measures 1 and 2 are related to vehicle electrification, specifically electrification of medium or heavy-duty diesel vehicles, and increasing light-duty vehicle charging infrastructure. Overarchingly, vehicle electrification will increase electricity consumption due to charging demands, which may have air quality disbenefits in communities located near power plants with air emissions.

While the shift towards EVs may create new job opportunities in car sales, EV maintenance, and repairs, it may also result in job losses for dealerships specializing in ICE vehicles and gas stations. The extent of these impacts will depend on the rate of EV adoption. Alternatively, auto service shops may not have the time, bandwidth, or funding to retrain staff in EV maintenance and repair or the means to secure the needed high-tech EV-specific equipment. Another disbenefit to EV adoption is additional registration fees in addition to typical vehicle registration fees implemented in NC to offset the decreases in gas tax revenue.[169] Presently the cost for EV registration is $214.50 in addition to typical vehicle registration fees and is adjusted for inflation every 4 years starting in 2020.[170]

Measure 3 described many projects at North Carolina's ports, both on the coast and inland. Local disbenefits related to investing in port infrastructure include impacts associated with increased construction, including noise, dust, and traffic around the port site albeit these impacts are short-lived in relative comparison to the GHG, and other air pollutant emission reductions realized in the same area.

Measure 9 notes that for the industry sector there are no incentives to reduce GHGs without funding or workforce development, therefore this sector will continue to increase GHG emissions which impact the economy-wide achievement of net-zero emissions by the 2050 target.

Measures 13 and 14, Natural Working Lands, show that land conservation, restoration, and tree planting may lead to increased property values of surrounding areas, which can exacerbate already present challenges of housing affordability and access to land ownership.

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[169] *NC GS 2015-241.* https://www.ncleg.gov/Sessions/2015/Bills/House/PDF/H97v9.pdf

[170] https://www.ncsl.org/transportation/special-registration-fees-for-electric-and-hybrid-vehicles

Such disbenefits should be mitigated through a comprehensive approach of expanding housing access and increasing access to natural spaces for all.

5.6.2 Workforce

Presently, NC is experiencing a major shortage in installation, maintenance, and repair jobs, with 8,300 fewer workers than are currently being hired by employers. Many of these occupations work across industries such as manufacturing and construction and are often skilled trades people. Therefore, if skilled workers switch jobs to support clean energy, there may be shortages in sectors that are not related to clean energy.

Other potential disbenefits include exclusion from job transition and training, potential job loss, and potential exclusion from energy saving technologies and services. Job training and job transition must consider how poverty and low wages are concentrated in rural communities, which leads to the need for employment transition opportunities. As GHG reduction activities may dampen the activities of fossil fuel industries, job loss could occur in these areas. Lastly, energy efficiency upgrades, home weatherization, solar technology, and other GHG reduction activities for individual residential use may be inaccessible financially for rural communities even though many of the programs in NC are designed to target residents in these communities.

6 Meaningful Engagement

North Carolina's CCAP planning process was guided by an intentional and inclusive public engagement effort that aimed to involve residents, local governments, community-based organizations, and tribal entities in shaping the plan. While the CCAP is a planning document without implementation funding, the engagement process was structured to surface locally informed priorities, identify climate-related needs, and ensure that public input helped guide the development of greenhouse gas (GHG) reduction strategies.

NCDEQ's engagement approach emphasized access, transparency, and geographic diversity. Events were held both virtually and in-person, and materials were made available through the state's CPRG webpage, email, and regional networks. Sessions invited discussion around climate risks, community needs, and barriers to action—particularly in rural and low-income areas with high energy burdens. NCDEQ also conducted follow-up interviews with participants from earlier sessions to explore more deeply the challenges and opportunities they face.

Community insights gathered through this process did not determine specific implementation locations, but they helped inform which strategies were considered most relevant and actionable. In several cases, stakeholder input led to the inclusion of updated local climate or resiliency plans, helping ensure that the CCAP reflects efforts already underway in municipalities and counties across the state. This helped strengthen the benefits analysis by illustrating where co-benefits such as air quality improvements, energy cost savings, or workforce potential may be most needed.

Additional details on the community identification, engagement methods, and results are provided in the sections that follow.

6.1 Community Identification

To ensure the equitable distribution of benefits under the Comprehensive Climate Action Plan (CCAP), North Carolina developed an approach for identifying communities that are rural in nature, have a low-income status, and are most impacted by energy costs.

North Carolina's definition focuses on census tracts or counties that meet one or more of the following characteristics:

- **Rural status**, as defined by the U.S. Department of Agriculture's Rural-Urban Commuting Area (RUCA) Codes. Areas with RUCA codes ≥4 are considered rural for the purposes of this analysis. The map data was retrieved from NC Department of Transportation Rural Planning Organization.[171]
- **Low-income status**, based on North Carolina's High-Poverty Areas for Title 1 Workforce Innovation and Opportunity Act (WIOA). Census tracts with a weighted

[171] *U.S. Department of Agriculture, Economic Research Service. (n.d.). Rural-Urban Commuting Area Codes. U.S. Department of Agriculture. https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes*

poverty rate of 25% or above household and the median income is below 200% of the federal poverty level.[172]

- **High energy burden**, identified though the NC Housing Coalition data from the 2019 NC Clean Energy Plan. The assessment is based on the percentage of NC renters and homeowners below the federal poverty level, correlating the fact that low-income households do not live in or cannot afford upgrades for an energy efficient home.[173]

Each community is evaluated based on how many of these criteria it meets. Communities that meet all three are designated as core priority areas. Those that meet two of three are considered highly impacted, and those meeting only one are flagged as potentially vulnerable. This tiered structure helps capture a broader cross-section of need than any one metric or tool would allow.

By adopting this approach, the state can better account for the diverse geographic, demographic, and energy-related disparities present in North Carolina. These areas are not well-captured by national screening tools. This methodology provides a more nuanced and locally relevant understanding of where climate planning efforts could focus to maximize equity and impact. As future climate investments become available, this framework can help guide outreach, analysis, and resource allocation to ensure that benefits reach communities experiencing the greatest energy and economic burdens.

The communities identified through this analysis have been included in Figure 19, Figure 20 and Figure 21.

[172] *North Carolina Department of Commerce. (n.d.). Workforce Innovation and Opportunity Act. North Carolina Department of Commerce. https://www.commerce.nc.gov/jobs-training/workforce-professionals-tools-resources/workforce-innovation-and-opportunity-act*

[173] *North Carolina Department of Environmental Quality. (n.d.). Electricity rates and energy burden. North Carolina Department of Environmental Quality. https://files.nc.gov/ncdeq/climate-change/clean-energy-plan/3.-Electricity-Rates-and-Energy-Burden-FINAL.pdf*

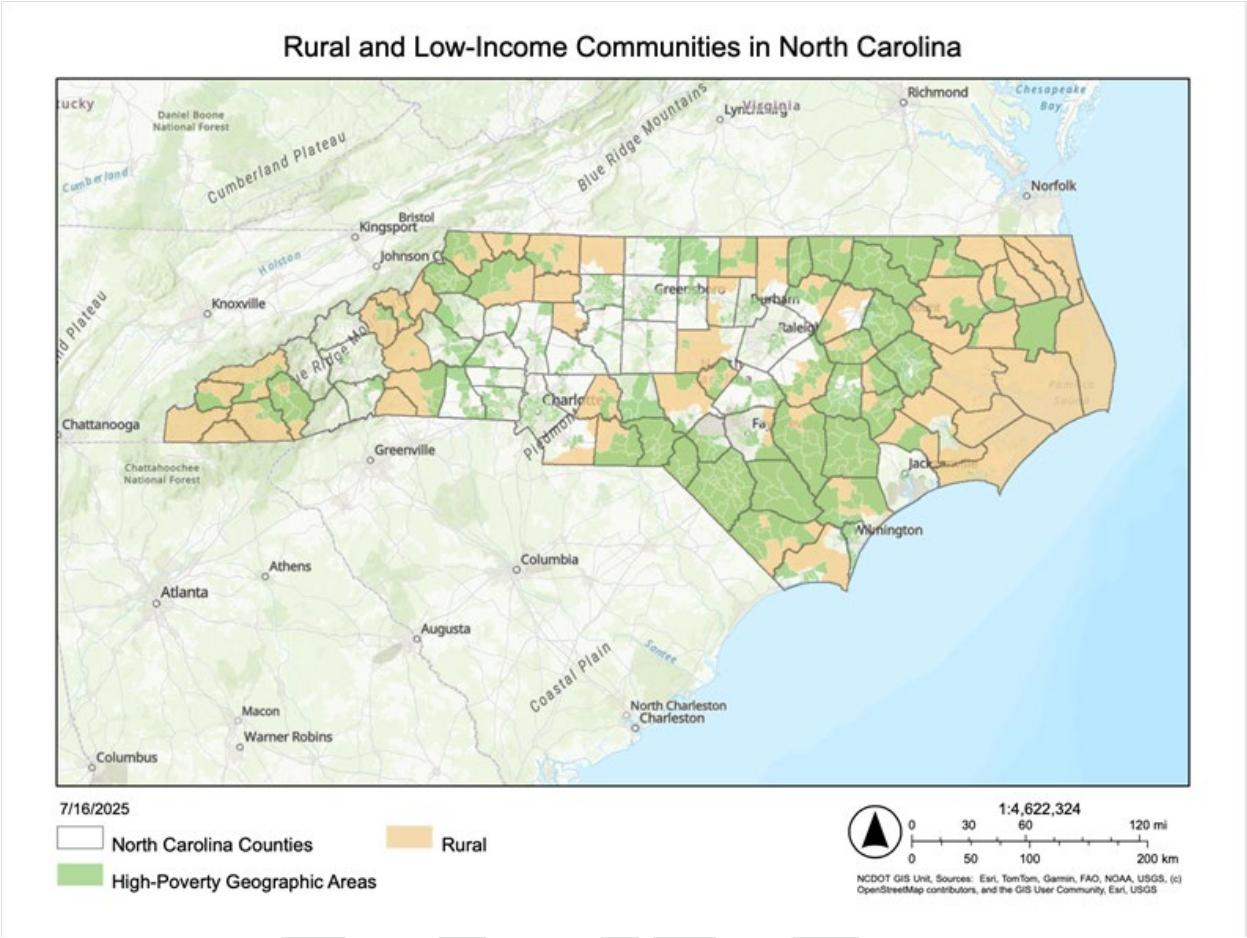

Figure 21. Map of Rural and Low-Income Communities in North Carolina

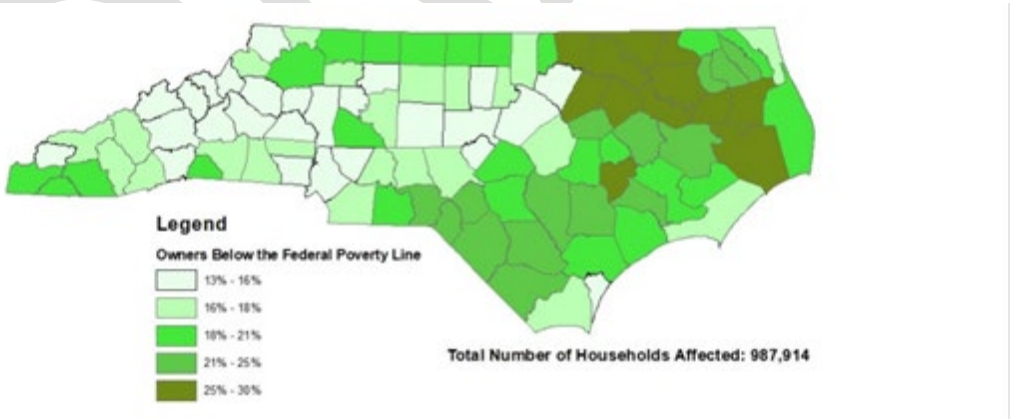

Figure 22. Average Energy Burden For Low Income Homeowners, North Carolina Counties, 2018

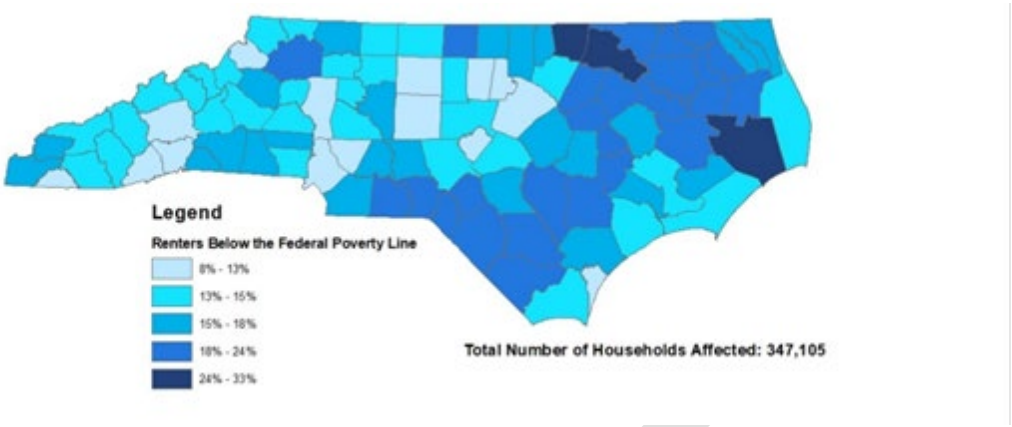

Figure 23. Average Energy Burden For Low Income Renters, North Carolina Counties, 2018

6.2 Meaningful Engagement Methods and Results

6.2.1 Engagement Methods

NCDEQ designed and implemented a multi-pronged community engagement strategy to support the development of North Carolina's Comprehensive Climate Action Plan (CCAP). The approach emphasized regional reach, transparency, and inclusion, with the goal of creating space for all North Carolinians to meaningfully participate in the planning process. Outreach focused on local and regional governments, tribes, public agencies, nonprofit organizations, and residents, particularly in rural and historically underrepresented areas. Events are detailed in Table 46.

Key engagement methods included:

- **Public and Stakeholder Events:** NCDEQ held a series of seven listening sessions between February and March 2025, including two virtual town halls and five in-person meetings in diverse geographic regions—Pembroke, Fayetteville, Morganton, Roanoke Rapids, and Wilmington. Events were open to the public and promoted via the CPRG webpage, press releases, social media, and existing partner networks.
- **Web-Based Tools and Communication Channels:** The CPRG program webpage served as the primary platform for accessing up-to-date information and submitting input. An online survey allowed respondents to share local project ideas and priorities, while a public email address (CPRG@deq.nc.gov) and phone line offered additional ways to submit comments or questions.
- **Tribal Outreach:** NCDEQ shared information and engagement opportunities with the NC Commission of Indian Affairs and tribal-serving organizations, including Lumbee River Electric Membership Corporation (EMC). These efforts resulted in direct tribal participation in public sessions and encouraged submissions of project ideas through the survey. Outreach emphasized that tribal communities could shape the direction of the CCAP by highlighting local priorities, including energy cost burdens, clean transportation needs, and residential building challenges.

- **Spotlight Interviews:** Following the initial engagement events, NCDEQ conducted a series of in-depth interviews with participants who had attended earlier sessions. These Spotlight Interviews were designed to capture more personal and place-based insights about climate risks, current mitigation projects, and barriers to action. Interviewees discussed their experiences with energy efficiency programs, the role of climate education in their communities, and the need for accessible funding and workforce development. The interviews helped illustrate how climate strategies intersect with public health, education, and economic opportunity.
- **Partnerships and Coordination:** NCDEQ collaborated with multiple state agencies—including the Departments of Transportation, Commerce, and Natural and Cultural Resources—and kept the Governor's Office informed of CPRG milestones. Regional entities such as the Centralina and Central Pines Regional Councils and EDF Cities Initiative also helped expand outreach. The Community Engagement Team supported culturally responsive engagement, including offering language interpretation services when needed to accommodate Spanish-speaking communities.

Table 47. CPRG Events Held by NCDEQ

Date	Description	Stakeholder(s)	Attendance
February 25, 2025	Virtual Kick-Off	Multiple/public	43
February 27, 2025	In- Person Event Lumbee River Electric Membership Corporation (Pembroke)	Multiple/Public	6
March 4, 2025	Virtual	EDF Cities Initiative	34
March 6, 2025	In-person community event (Fayetteville)	Multiple/public	5
March 13, 2025	In-person community event (Morganton)	Multiple/public	2
March 20, 2025	In-person community event (Roanoke Rapids)	Multiple/public	8
March 27, 2025	In-person community event (Wilmington)	Multiple/public	3

6.2.2 Engagement Results

The engagement process generated strong participation and yielded a range of valuable insights that informed both the structure and substance of the CCAP. Although the plan itself does not fund implementation, community feedback helped shape the selection and refinement of GHG reduction strategies by highlighting local needs and reinforcing the relevance of certain sectors and priorities.

Key participation outcomes:

- **141 individuals** registered for at least one public session
- **48 organizations** were represented, including municipalities, counties, tribal organizations, utilities, non-profits, and academic institutions
- **86 pieces of direct feedback** were submitted via discussion, email, and online tools
- **110 survey responses** provided project ideas and comments
- **385 Menti poll responses** were collected during live sessions
- **1,340 unique visitors** accessed the CPRG webpage from January to October 2025

Attendees expressed interest in a wide array of topics, including energy affordability, electric vehicle infrastructure, clean energy workforce development, climate education, and local adaptation needs. In several cases, municipalities and regional partners submitted updated climate or resilience plans, some of which were reflected in the CCAP's measure development and economy-wide analysis.

6.2.3 Spotlight Interviews - A closer look

Spotlight Interviews provided deeper insight into how local organizations and individuals are already taking steps to reduce greenhouse gas emissions. Interview participants included representatives from the Center for Energy Education, the Clean Air Task Force, Lumbee River EMC, and several municipal governments. Conversations highlighted on-the-ground initiatives such as school-based energy efficiency programs, community-led weatherization efforts, and public education campaigns linking energy savings with career pathways in clean energy. These interviews helped illustrate the critical role of community-led action in complementing broader state strategies.

Figure 24. Spotlight Interview - Working Landscapes

Figure 25. Spotlight Interview - NCIHA

Figure 26. Spotlight Interview - Sustainable Sandhills

Participants across the engagement process emphasized that reducing GHG emissions is not solely the responsibility of large institutions. Individual choices—such as home weatherization, switching to electric appliances, participating in local planning efforts, or pursuing clean energy careers—can collectively make a significant impact. The feedback received reinforced that climate action must be approached not just as a technical challenge, but as a shared public effort grounded in community priorities, lead by state planning and funding, and embraced with shared experiences.

7 Workforce Planning Analysis

This section summarizes key findings from a workforce analysis conducted by the North Carolina Department of Commerce to inform the development of the Comprehensive Climate Action Plan (CCAP). While the analysis was developed prior to the finalization of CCAP's greenhouse gas (GHG) reduction measures, it provides critical context regarding statewide workforce trends, gaps, and readiness for supporting climate-related implementation. The report models expected job growth across several clean energy sectors and highlights key occupations, barriers to employment, and workforce development assets. The full analysis is included as Appendix D.

7.1 Summary of Key Findings

Workforce Opportunities Across CCAP Sectors

Under a modeled "Growth Scenario," which assumes achievement of North Carolina's climate goals by 2050, the state could gain approximately 9,650 additional jobs annually across key CCAP sectors. This includes:

- **Wind Energy:** ~5,500 jobs/year driven by onshore wind construction, operations, and maintenance.
- **Solar Energy:** ~3,000 jobs/year in installation, logistics, and project development.
- **Electric Vehicles (EVs):** ~1,000 jobs/year, particularly in battery production, charging infrastructure, and utilities.
- **Building Efficiency:** <150 jobs/year, primarily in HVAC, weatherization, and energy auditing.

Cumulatively, these sectors could contribute over $49 billion in economic impact by 2050.

7.2 Occupational Demand and Gaps

The occupations most in demand include construction laborers, electricians, HVAC technicians, solar photovoltaic installers, and energy auditors. The state faces a current shortfall of 8,300 workers in installation, maintenance, and repair roles—a critical bottleneck for CCAP implementation. Despite an overall surplus of jobseekers in some occupational categories like administration and management, employers continue to report difficulty filling key roles due to a shortage of skilled applicants.

Workforce Readiness Infrastructure

North Carolina benefits from a robust training ecosystem, including 58 community colleges, over 70 NCWorks Career Centers,[174] and multiple apprenticeship and sectoral training

[174] *NC Careers. (n.d.). NCWorks Career Centers. NC Careers. Retrieved July 30, 2025. https://nccareers.org/ncworks-career-centers*

initiatives that are further described below. Programs such as ApprenticeshipNC,[175] NCEdge,[176] and Certified Career Pathways are well-positioned to expand clean energy workforce pipelines.

Alignment with CCAP Measures

The workforce analysis provides foundational insight into sector-specific labor needs aligned with North Carolina's CCAP measures, as shown here in Table 47:

Table 48. NC DEQ CCAP Workforce Analysis

Sector	Relevant Measures	Key Workforce Impacts Identified
Residential & Commercial Buildings	Measures 7–8	HVAC, insulation, energy auditing; retrofit demand; WAP/HEAR/HOMES expansion
Transportation	Measures 1–2, 11	EV charger installation, EV maintenance, battery manufacturing
Electricity	Measures 5–6	Solar PV, wind turbine construction, electrical trades
Natural & Working Lands	Measures 13–14	Conservation, restoration, forestry management; local hiring in rural areas

The alignment of these sectors in the workforce report helps establish a strategic foundation for future planning and economic development.

Equity and Priority Communities

The workforce analysis underscores the importance of equity in workforce access and job placement. It highlights that more than 750,000 North Carolina households pay over $250/month for electricity, with the burden particularly acute in eastern counties. Many of these areas also face workforce participation challenges tied to transportation, childcare, and jobsite proximity. The analysis points to a strong opportunity to align CCAP implementation with targeted investments in rural, low-income, and energy-burdened communities.

7.3 Workforce Development Strategies and Tools

North Carolina is actively advancing clean energy workforce readiness through multiple strategies:

- **ApprenticeshipNC:** Rapidly growing model for skilled trades training with strong rural participation (e.g., Surry-Yadkin Works).

[175] *North Carolina Community Colleges. (n.d.). Apprenticeships. North Carolina Community Colleges. Retrieved July 30, 2025. https://www.nccommunitycolleges.edu/businesses/apprenticeships/*
[176] *NC Community Colleges. (n.d.). NCEdge. Retrieved July 30, 2025, from https://www.nccommunitycolleges.edu/businesses/ncedge/*

- **NCEdge:** Customized employer-driven training available statewide through the community college system.
- **Certified Career Pathways:** Integrated education-to-career models that align with clean energy and advanced manufacturing occupations.
- **Industry Partnerships:** Programs like AdvanceNC[177], EVeryone Charging Forward,[178] and the NC Battery Industry Partnership (NCBIP)[179] offer scalable training pathways and employer engagement.
- **Digital Tools:** Platforms such as NCWorks Online and NCCareers.org provide access to job matching, skills assessment, and labor market data.

7.4 Next Steps

As North Carolina continues to transition to more renewable energy resources, the Commerce workforce analysis will serve as a key document for designing programs that support equitable job growth and labor force development across CCAP measures. NCDEQ will continue to coordinate with Commerce, workforce boards, and training providers to ensure that clean energy implementation efforts are supported by a prepared and inclusive workforce. Future updates to the CCAP will incorporate ongoing labor market insights and adjustments to workforce demand as progress within the measures continues.

8 Key Definitions

Priority Climate Action Plan (PCAP): a narrative climate planning report that includes a focused list of near-term, high-priority, and implementation-ready measures to reduce GHG pollution and an analysis of GHG emission reductions.

Comprehensive Climate Action Plan (CCAP): a narrative climate planning report that provides an overview of all GHG sources/sinks and sectors following industry standard protocols. The CCAP will establish near-term and long-term GHG emission reduction targets and identify GHG reduction measures to achieve those goals.

Greenhouse Gas (GHG) Inventory: a summary of all GHG emission sources and sinks by sector and the associated emissions quantified using commonly accepted protocols. The CCAP must include a comprehensive inventory of GHG emissions and sinks for the following sectors: industry, electricity generation/use, transportation, commercial and residential buildings, agriculture, natural and working lands, and waste and materials management.

Metropolitan Statistical Area (MSA): metropolitan statistical areas as defined by the U.S. Census 2020 MSA population. A list of eligible MSAs can be found in Appendix 15.2 of in EPA's CPRG: Formula Grants for Planning, Program Guidance for States, Municipalities, and Air Control Agencies.

[177] *AdvanceNC. (n.d.). Retrieved July 30, 2025, from https://advancenc.com/*
[178] *https://ncbce.org/everyone-charging-forward/*
[179] *https://www.linkedin.com/groups/13176745/*

State: all 50 U.S. states and the District of Columbia and Puerto Rico. U.S. federally recognized Tribes and Territories (the Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands) must follow CRPG guidance for Tribes and Territories.

9 Appendices

The following appendices provide additional technical detail for each of the greenhouse gas (GHG) reduction measures included in Section 5.3 of this plan. These materials offer supporting documentation that expands upon the summary information presented in the main report.

Each appendix is linked to a specific section in the report and may include, where applicable, the data sources, modeling approaches and methodologies, assumptions, emission factors, cost estimates, and program context. Together, these appendices reinforce the connections between the state's GHG Inventory and BAU Projections, the Quantifying GHG Reductions and Measures methodology, and the broader framework of Meaningful Engagement, and Workforce Analysis Reporting.

In keeping with the planning constraints outlined throughout the CCAP, the appendices reflect an intentional focus on currently funded and ongoing programs. They are not meant to propose or evaluate unfunded measures, but to document realistic emission reduction outcomes based on available data.

Appendix A. NC GHG Inventory and BAU Projections

1.1. Methodology

The methods described in this section reflect the most current GHG Inventory and BAU Projections available to NCDEQ. The GHG Inventory is scheduled to be updated in 2026 and this section may be updated with additional information later.

Additional information about the state's GHG inventory may be found at: https://www.deq.nc.gov/energy-climate/climate-change/greenhouse-gas-inventory

The historical GHG emissions are calculated to show how emissions in NC have changed from 1990 through 2020, the last year of available historical data in the U.S. Environmental Protection Agency State Inventory Tool (SIT), a spreadsheet-based tool developed by EPA and designed to assist state agencies in preparing state-level GHG inventories and projections.[1] For this inventory, the NCDEQ Division of Air Quality (DAQ) developed updated 1990-2020 emissions estimates for all sectors.

The historical GHG emissions were primarily prepared using the SIT. The SIT simplifies the effort for preparing state-level GHG inventories that is generally consistent with EPA's national inventory. The SIT applies a "top-down" approach to calculate GHG emissions from all relevant anthropogenic source sectors and uses methodologies consistent with those recommended in the 2006 IPCC Guidelines.[2] The use of consistent methodologies ensures that GHG inventories prepared by various entities are comparable.

The SIT is organized into 12 modules for calculating historical emissions and one module for projecting emissions.[3] However, these modules do not correspond to the layout of the sector and source emissions tables presented in the CCAP. Instead, they are organized to facilitate the emissions estimation process. Each module has a User's Guide that outlines the methodology, and documents the default data sources, emission factors, references, and other pertinent information utilized by the module. There is also a synthesis module which pulls the historical emissions data from each module into a single spreadsheet tool to assist in generating reports and graphics.

The SIT includes default data supplied by EPA. The default data are generally publicly available from various federal agencies. A limited number of source categories utilize data obtained from third-party vendors. The default data in the SIT are also frequently used by

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[1] EPA. "State Inventory and Projection Tool." https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool, accessed June 2023.

[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. Hayama, Kanagawa, Japan, 2006.

[3] NC only utilizes 12 of these 13 modules because one module estimates emissions from coal production which does not occur in NC.

state and local agencies to develop emission inventories for other air pollutants. For a select number of source categories, the DAQ has replaced the SIT default data with data obtained from NC's state agencies. These data support the development of more accurate emissions estimates for the state. The historical emissions estimation methodologies, and default and substituted data sources used in each module, are presented below.

A detailed discussion of the uncertainty associated with the SIT default data used for the historical GHG emission inventory is outlined in each of the SIT modules, which are available for download from the EPA SIT webpage.[4]

1.2. CO_2 Emissions from Fossil Fuel Combustion

1.2.1. Description

The SIT Fossil Fuel Combustion Module calculates CO_2 emissions from combustion of fossil fuels including coal, natural gas, and petroleum products. The sectors included in the module are listed below.[5]

Residential	Industrial	Transportation
Commercial	Electric Power	

It also calculates CO_2 that is stored or released using fossil fuels in the production of solvents, asphalt, synthetic rubber, naphtha, lubricants, and other products.

CH_4 and N_2O emissions from fossil fuel combustion are calculated in two separate modules, the Mobile Combustion Module and the CH_4 and N_2O Stationary Combustion Module.

1.2.2. Background and Default Data

The methodology for estimating CO_2 emissions from fossil fuel combustion is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[6]

The default historical fuel consumption data provided in the SIT module for NC are used without any adjustments. These default data, which consist of the estimated amount of

[4] *EPA. "State Inventory and Projection Tool."* https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool, *accessed June 2023.*

[5] *The Fossil Fuel Combustion Module estimates emissions from international bunker fuel use. These emissions are from international transportation; therefore, they are not included in state inventories.*

[6] *EPA. "User's Guide for Estimating Direct Carbon Dioxide Emissions from Fossil Fuel Combustion Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.*

each type of fuel consumed by each sector in each state, are from the Energy Information Administration's (EIA) State Energy Data System (SEDS).[7]

Note that the SIT estimates non-combustion consumption of Industrial sector fuel for each fossil fuel type.

1.2.3. Deviations from Defaults

Wood, ethanol, and biodiesel are biomass fuels for which CO_2 emissions are excluded from gross GHG emissions. To provide additional transparency, however, the DAQ developed CO_2 emissions estimates for the consumption of these biomass fuels in NC.

1.2.4. Future Refinements

Future refinements for biomass emissions estimates could investigate the availability of data for estimating CO_2 emissions from the combustion of landfill and manure gas.

1.3. CO_2 Emissions from Transportation

For the onroad mobile source sector, the DAQ applied the 4.0.0 version of EPA's MOVES4 model to estimate emissions for the key years of 2005 and 2021.[8] The MOVES4 model is used in place of the SIT because it is EPA's official onroad mobile source emissions estimation model, it facilitates consistency with all other DAQ onroad mobile source emissions estimation efforts, and it provides emissions forecasting and policy analysis capabilities that are not available from the SIT. Because of the time and resources necessary for performing a MOVES4 run for a given year, it was necessary for the DAQ to limit use of MOVES4 to two historical years: 2005 and 2021. The year 2005 was chosen because it is the baseline year specified by various federal, multi-state, and NC-specific GHG mitigation policies, and 2021 because it was the latest year for which we had a complete set of historical data.

Because ethanol is a biomass fuel, it was necessary to adjust the CO_2 emissions output from MOVES4 to subtract ethanol-related emissions. The DAQ developed adjustment values for 2005 and 2021 from EIA SEDS transportation sector fuel heat input data to back out estimated ethanol-related CO_2 emissions. In 2005, ethanol contributed 0.39% of heat input to transportation sector motor gasoline in NC, and this contribution rose to 6.88% in 2021. The DAQ reduced the CO_2 emission estimates from MOVES4 for these two years using these heat input percentages.

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[7] *EIA. "State Energy Data System (SEDS): 1960-2021 (complete)." June 2023.*

[8] *EPA. "MOVES4: Latest Version of Motor Vehicle Emission Simulator." https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves. Accessed September 2023.*

To estimate pre-2005 onroad mobile source emissions, the DAQ relied on emission trends generated by the SIT's Mobile Combustion Module (see discussion in the following section). Specifically, the DAQ calculated pre-2005 adjustment factors reflecting the SIT's 1990-2005 emission trends, and then multiplied these factors by the 2005 MOVES4-based emission values. The MOVES4 model was run with output options allowing reporting of results by vehicle regulatory class categories as well as by the default MOVES4 vehicle use categories. The MOVES4 output was also broken down by fuel type. This allowed better alignment of MOVES4 output data with the vehicle and fuel categorizations used in the SIT.

Because a review of the SIT default VMT data, which had originally been compiled by FHWA and EPA, indicated anomalous values for certain years, the DAQ coordinated with the NC Department of Transportation (NCDOT) to develop VMT data that revised the SIT default values. The DAQ's review of the 2005 VMT data identified substantial differences when compared to the 2005 Highway Performance Monitoring System (HPMS) VMT data published by FHWA. Consultation with NCDOT revealed that for years 2008 and earlier, NCDOT used a methodology that tracked VMT on state-maintained roads and locally maintained roads separately, with fewer traffic counts conducted for roadways with lower traffic volume. The NCDOT VMT data for these years was consistently lower than the corresponding FHWA HPMS data. To improve HPMS VMT data quality, the FHWA changed the state VMT reporting requirements in 2009. To meet these new requirements, NCDOT added traffic count stations to cover lower-functional class roadways and implemented geographic information system-based processes for tracking VMT. This has led to consistency between the VMT data reported by NCDOT and the HPMS VMT data published by FHWA for 2009 and subsequent years. Based on methods recommended by NCDOT, the 1990-2008 VMT data were adjusted by the DAQ to be consistent with the 2009 and later HPMS data. The 2005 VMT data disaggregated at the county-level were used for GHG emissions modeling with MOVES4. For the 2021 GHG emissions modeling, the DAQ used the county-level VMT data directly as provided by NCDOT. No revisions were warranted because NCDOT VMT tracking and reporting procedures were aligned with FHWA HPMS requirements beginning in 2009.

The DAQ developed 2006-2020 onroad CO_2 emission estimates in three steps. The first step was to develop 2006-2020 VMT estimates for the vehicle/fuel type output by MOVES4. These estimates were calculated from state-level VMT for 2006-2020 and interpolated ratios of each vehicle/fuel type's VMT in that year to the state total VMT. The second step was to develop 2006-2020 CO_2 emission factors for the vehicle/fuel type output by MOVES4. These factors were developed by interpolating between the years 2005 and 2021 emission factors that were computed from MOVES4 output for those two years. The final step was to multiply the vehicle/fuel type VMT in each year by the CO_2 emission factors for the vehicle/fuel type in that year.

For the remainder of the Transportation sector, which covers non-highway sources including aircraft, locomotives, and boats, the DAQ generally used the CO_2 emissions estimation methods/data incorporated into the SIT's CH_4 and N_2O Emissions from Mobile

Combustion Module. The DAQ replaced SIT default jet fuel consumption data for aircraft for select years after identifying suspect trends in the SEDS transportation sector jet fuel consumption data that are used to estimate aviation emissions. A review of these SEDS data indicates that, beginning with year 2010, the EIA adopted a substantially different methodology for estimating jet fuel sales. To develop a more consistent series of jet fuel consumption, the DAQ applied the 1990-2010 trend in total NC landing and take-off operations for commercial and military aircraft to backcast NC jet fuel consumption for the years 1990-2009.[9]

In addition, estimates were developed to adjust the SIT's fuel consumption estimates for aircraft and boats to remove international bunker fuels (i.e., fuels consumed outside of the U.S.). Because NC-specific data were not available to perform this adjustment, the DAQ used emissions data from EPA's national GHG inventory to develop these adjustment factors.[10]

1.3.1. Future Refinements

Future refinements could include additional research into ways to better perform the international bunker fuel adjustments to reflect NC activity.

1.4. CH_4 and N_2O Emissions from Mobile Combustion

1.4.1. Description

The SIT Mobile Combustion Module calculates CH_4 and N_2O emissions from the following mobile sources:

Gasoline Highway	Non-Highway
Diesel Highway	Alternative Fuel Vehicles

CO_2 emissions from the Transportation sector are calculated as discussed below. The Mobile Combustion Module provides an alternate method for calculating CO_2 emissions for highway vehicles that the DAQ used to extrapolate trends in vehicle CO_2 emissions for historical years not modeled via MOVES4.

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[9] *Federal Aviation Administration. "The Operations Network (OPSNET) > Airport Operations." https://aspm.faa.gov/opsnet/sys/Airport.asp. Accessed December 2023.*

[10] *EPA. Table 3-13, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021." EPA 430-R-23-002. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021. Accessed December 2023.*

1.4.2. Background and Default Data

The methodology for estimating CH_4 and N_2O emissions from mobile combustion is provided in the User's Guide for the SIT module as well as instructions and information provided in the spreadsheets for each module.[11]

For highway/alternative fuel vehicles, CH_4 and N_2O emissions can be calculated in the SIT based on several factors including VMT, fuel type, engine type, and control technology type for the population of vehicles on roads in NC. However, as noted below, the DAQ used the MOVES4 model to calculate highway vehicle emissions.

CH_4 and N_2O emissions from non-highway mobile sources (e.g., aviation, marine, locomotives, construction equipment) and other non-highway equipment are derived from fuel consumption estimates. The default historical non-highway mobile source fuel consumption estimates provided in the SIT module for NC were used, except where noted above (CO_2 Emissions from Transportation).

1.4.3. Deviations from Defaults

For consistency with the development of highway vehicle CO_2 emission, the DAQ compiled CH_4 and N_2O estimates from the same 2005 and 2021 MOVES4 runs and extrapolation/interpolation procedures that were used to develop onroad vehicle CO_2 estimates. The VMT data that were used to calculate CH_4 and N_2O emissions were the same data that were used to estimate CO_2 emissions.

1.4.4. Future Refinements

No future refinements have been identified at this time.

1.5. CH4 and N2O Emissions from Stationary Combustion

1.5.1. Description

The SIT Stationary Combustion Module calculates CH_4 and N_2O emissions at stationary sources combusting (1) fossil fuels including coal, natural gas, and petroleum products, and (2) biofuels. The source sectors included in the module are listed below.

Residential	Industrial
Commercial	Electric Power

[11] *EPA. "User's Guide for Estimating Methane and Nitrous Oxide Emissions from Mobile Combustion Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, September 2020.*

It also calculates CH_4 and N_2O that are stored or released using fossil fuels in the production of solvents, asphalt, synthetic rubber, naphtha, lubricants, and other products. Stationary Combustion CO_2 emissions are calculated in the Fossil Fuel Combustion Module as discussed above.

1.5.2. Background and Default Data

The methodology for estimating CH_4 and N_2O emissions from fossil fuel and biofuel stationary sources is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[12]

The default historical fuel consumption data provided in the SIT module for NC are used without any adjustments. These default data are from the EIA's SEDS.[13] It consists of the estimated amount of each type of fuel consumed by each sector.

Note that for the Industrial sector, the SIT also estimates consumption of fuel for non-combustion use for each fossil fuel type.

1.5.3. Deviations from Defaults

No data or estimation methods outside of those provided by the SIT are utilized in calculations.

1.5.4. Future Refinements

No future refinements have been identified at this time.

1.6. Natural Gas and Oil

1.6.1. Description

The SIT Natural Gas and Oil Module calculates CH_4 (and its CO_2e) emissions from Natural Gas and Oil systems. The subsectors included in the module are listed below.

Natural Gas Production	Natural Gas Distribution
Natural Gas Transmission	Petroleum Production, Refining, and Transportation

[12] *EPA. "User's Guide for Estimating Methane and Nitrous Oxide Emissions from Stationary Combustion Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.*

[13] *EIA. "State Energy Data System (SEDS): 1960-2021." https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption. Accessed September 2023.*

GHG emissions from the combustion of natural gas and oil are calculated in the Fossil Fuel Combustion Module as discussed below.

1.6.2. Background and Defaults

The methodology for estimating GHG emissions from Natural Gas and Oil systems is summarized in the User's Guide for the module, as well as information provided in the module's spreadsheets.[14] Default activity data are generally not provided in the Natural Gas and Oil Module of the SIT. The focus for NC was the Natural Gas Transmission and Distribution sectors because the State does not produce or refine any oil or natural gas. CH_4 emission factors in the module for Natural Gas Transmission and Distribution are taken from a study conducted by the Gas Research Institute and EPA.[15] The CH_4 emission factor for natural gas transmission compressor stations used the module's default value of 983.66 metric tons (MT) per compressor station from 1990-2012 because these are years before data were available for estimating NC-specific compressor station emission factors from EPA's GHG Reporting Program.

1.6.3. Deviations from Defaults

A review of the NC emissions data reported to EPA's GHG Reporting Program suggested two periods with significantly different natural gas transmission compressor CH_4 emission rates. The CH_4 emissions factor for natural gas transmission compressor stations was calculated to be 500 metric tons/station from 2013-2014 and 300 metric tons/station from 2015-2020. These updated values reflect the approximate median values calculated from CH_4 emissions reported by NC compressor stations to EPA's GHG reporting program for each timeframe.[16] The 2010-2020 natural gas transmission pipeline miles data are input into the module were obtained from a NC query performed on the webpage of the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA).[17] Natural gas distribution pipeline miles in NC by material and natural gas service data for select years (1990-1997, 2000, 2002, 2004-2005, 2007, 2009-2020) were compiled from PHMSA files.[18] Values for other years were estimated via interpolation.

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[14] EPA. "User's Guide for Estimating Carbon Dioxide and Methane Emissions from Natural Gas and Oil Systems Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.

[15] Gas Research Institute and EPA. "Methane Emissions from the Natural Gas Industry, EPA-600/R96-080a and GRI-94/0257." June 1996. https://www.epa.gov/sites/production/files/2016-08/documents/1_executiveummary.pdf.

[16] EPA Greenhouse Gas Reporting Program. "Find and Use GHGRP Data." https://www.epa.gov/ghgreporting/find-and-use-ghgrp-data. Accessed December 2023.

[17] PHMSA. "2010+ Pipeline Miles and Facilities." https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities. Accessed October 2023.

[18] PHMSA. "Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data." https://www.phmsa.dot.gov/data-and-statistics/pipeline/distribution-transmission-gathering-lng-and-liquid-annual-data. Accessed October 2023.

According to the PHMSA there were five liquefied natural gas liquefaction and storage facilities and 13 natural gas compressor stations operating in NC in 2020.[19] Due to a lack of historical data, the NCUC facility/station counts are used for all pre-2020 years. There were no natural gas venting and flaring operations associated with natural gas production in NC from 1990-2020 based on EIA information.[20]

1.6.4. Future Refinements

The EPA's GHGI incorporates a major change to the methodology for this sector. In future revisions to the inventory for this sector, the DAQ will evaluate the merits of this alternative approach relative to the SIT methodology.

1.7. Imported Electricity

1.7.1. Description

Imported electricity is the amount of electricity that NC imports from power plants that are located outside the State via the regional electricity grid system. Note that emissions associated with generating imported electricity do not occur in NC. However, the emissions are generated due to the demand for electricity in NC, therefore, these emissions can be considered part of NC's carbon footprint. Since this electricity is coming from the regional electricity grid, the average emission factors developed by EPA for the regional grid that contains NC were used to estimate GHG emissions from imported electricity.

1.7.2. Background and Defaults

Because the SIT does not specifically estimate emissions associated with imported electricity, the DAQ developed an approach. In keeping with the use of fuel consumption estimates used elsewhere in the SIT, the DAQ used EIA SEDS data to reflect the amount of electricity imported into NC. The DAQ specifically used NC "net interstate flow" of electricity data from SEDS.[21] The SEDS "net interstate flow" of electricity represents the difference between the sum of electricity sales and transmission losses within a state and the total amount of electricity generated within that state.

The average GHG emission factors developed by EPA for NC's regional electrical grid (Southeastern Electric Reliability Council - Virginia/Carolina Subregion or SRVC) as part of the EPA's Emissions & Generation Resource Integrated Database (eGRID) are used to

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[19] *PHMSA. "2010+ Pipeline Miles and Facilities." https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities. Accessed October 2023.*

[20] *EIA. "Natural Gas Gross Withdrawals and Production." https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcf_a.htm. Accessed October 2023.*

[21] *EIA. "State Energy Data System (SEDS): 1960-2021 (complete)." https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#Consumption. Accessed October 2023.*

calculate emissions from imported electricity.[22] These emission factors are available on a per-kilowatt-hour-of-electricity basis. The EPA does not estimate emission factors for every year. If an emission factor is not available for a given year, the value for the first available year was used (e.g., 2004 CO_2 emission factor is used for all pre-2004 years), or an interpolated value was used. The GHG emissions from imported electricity are reported in the inventory under the "Electricity Generation and Use" sector.

1.7.3. Future Refinements

No future refinements have been identified at this time.

1.8. Agriculture

1.8.1. Description

The SIT Agriculture Module calculates CH_4 and N_2O emissions from agricultural operations. The subsectors included in the module are listed below.

Enteric Fermentation	Rice Cultivation	Agricultural Soils
Manure Management	Burning of Agricultural Crop Waste	

1.8.2. Background and Defaults

The methodology for estimating CH_4 and N_2O emissions from the Agriculture Sector is described within the SIT User's Guide for this module as well as instructions and information provided in the spreadsheets for each subsector of the module.[23] The default historical activity data provided in the SIT module for NC were used without adjustments for the burning of agricultural crop waste; agricultural soils – plant residues and legumes; and agricultural soils – plant fertilizer subsectors. Default animal population and crop production data in the module are from the USDA's National Agricultural Statistics Service (NASS). Because there is no rice production in NC, it is not necessary to perform calculations for the rice cultivation subsector. Default fertilizer use data are from the Association of American Plant Food Control Officials and The Fertilizer Institute. It should be noted that the module applies a national adjustment factor to reconcile differences between methodologies for estimating N_2O from agricultural soils between the SIT and EPA's national inventory.

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[22] EPA Clean Air Markets Division. "Download Data, eGRID with 2021 data." https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid. Accessed September 2023.

[23] EPA. "User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.

1.8.3. Deviations from Defaults

The default USDA data in the module were revised for the following livestock categories to reflect the most recent set of available livestock inventory estimates: beef cows; milk cows; goats; turkeys; and hogs. These data are from online queries of USDA datasets (note that USDA compiles these data sets in cooperation with the NC Department of Agriculture and Consumer Services).[24] These livestock data were used to calculate emissions for the following subsectors: enteric fermentation, manure management, and agricultural soils, animals and runoff.

1.8.4. Future Refinements

The agricultural soils – plant residues and legumes subsector does not include default production data for the following crop types: red clover, white clover, birdsfoot trefoil, arrowleaf clover, and crimson clover. Also, the agricultural soils – plant fertilizer subsector does not provide default data for the following organic types of fertilizers: compost, dried blood, dried manure, other sewage sludge, and tankage. Further research can be conducted to determine if it may be possible to supplement the default crop production and fertilizer use data with data for additional types of crops and fertilizers.

1.9. Municipal Solid Waste

1.9.1. Description

The SIT MSW module of the SIT calculates CH_4 emissions from landfilling MSW and CO_2 and N_2O from the combustion of MSW. Some landfills have added gas collection systems to collect and burn landfill gas (LFG) for electricity production and other energy uses (landfill-gas-to-energy projects or LFGTE). Other landfills flare LFG which converts the CH_4 portion to CO_2.

CO_2 emitted directly from landfills as biogas and CO_2 emitted from CH_4 combustion at the flares are not counted as anthropogenic GHG emissions in this inventory.

1.9.2. Background and Defaults

There are two subsectors in this module, landfills and combustion, and the emissions calculation methodology is different for each. The methodology for estimating GHG emissions from MSW is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for the module.[25]

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[24] USDA. "National Agricultural Statistics Service, Quick Stats." NC data obtained October 2023 via online query of data from https://quickstats.nass.usda.gov/.

[25] EPA. "User's Guide for Estimating Emissions from Municipal Solid Waste Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.

The default SIT values were used for landfill flaring which comes from EPA's Landfill Methane Outreach Project (LMOP) database.[26] Default population data from the US Census were included for the LFG emissions calculation.

The CH_4 emissions from industrial landfills in the SIT were assumed to be 7% of the MSW landfill emissions. No additional information has been found so the default value was used. Default fractions for plastics, synthetic rubber, and synthetic fiber combustion were also used.

1.9.3. Deviations from Defaults

For the landfill sector, total landfill disposal data from 1990 to 2022 were obtained from the NC Division of Waste Management.[27] These data are published in an annual report based on fiscal year, (July 1 through June 30 of the following year) and contain construction and demolition (C&D) debris. Since the SIT is based on calendar year rather than fiscal year, the disposal value was apportioned to the two partial calendar years represented by the fiscal year (half of the value is assigned to each year), then the two values from different fiscal years are summed to get the total for a calendar year. The C&D debris was apportioned in the same manner and subtracted from the disposal value. Each annual report encompassed a range of years so the report with the latest values for each year was used.

Information regarding LFGTE projects was extracted from EPA's LMOP database to estimate LFG annual flow and years of use.[28]

To maintain consistency with other modules, NC Office of State Budget and Management (OSBM) population data were used instead of the default population values.

1.9.4. Future Refinements

Further research into landfill flaring, CH_4 emissions from industrial landfills, and factors for the combustion of plastics, synthetic rubber and synthetic fibers would enhance the accuracy of the emission estimations.

1.10. Wastewater

1.10.1. Description

[26] *EPA. "Landfill Technical Data, Landfill and Landfill Gas Energy Project Database, Landfill Methane Outreach Program (LMOP)." https://www.epa.gov/lmop/landfill-technical-data. Accessed September 2023.*

[27] *NCDEQ. "Solid Waste Management Annual Reports." https://deq.nc.gov/about/divisions/waste-management/sw/data/annual-reports. Accessed September 2023.*

[28] *EPA. "Landfill Gas Energy Project Data, Landfill and Landfill Gas Energy Project Database, Landfill Methane Outreach Program (LMOP)." https://www.epa.gov/lmop/landfill-technical-data. Accessed September 2023.*

The Wastewater module of the SIT calculates CH_4 and N_2O emissions from the treatment of Industrial and Municipal Wastewater. The tool is separated into Municipal Wastewater and Industrial Wastewater sections. The Municipal Wastewater section calculates direct N_2O from biosolids, and CH_4 emissions. The Industrial section calculates CH_4 emissions from the fruit and vegetable, red meat, poultry, and pulp and paper industries.

1.10.2. Background and Defaults

The calculation methodology in the Wastewater module is complex and varies within the two sections. The methodology for estimating GHG emissions from Wastewater is provided by the User's Guide for this module as well as instructions and information provided on the spreadsheets for each module.[29]

The source for Municipal Wastewater default values for CH_4 emissions is reported as state and local public works agencies. The default data were used for the Municipal Wastewater section of this tool.

The Industrial section of this module provides default data for the red meat industry but not for the poultry, pulp and paper, or fruit and vegetable industries. The default red meat data were obtained from the USDA's NASS.[30]

1.10.3. Deviations from Defaults

No source of wastewater activity data for the fruits and vegetables industry was located.

Wastewater emissions for the pulp and paper industry are reported for 2003 and later years because these are the only years with emission source specific emissions covered by the DAQ's Internet-Based Enterprise Application Management – Emissions Data (IBEAM-ED). Other sources of pulp and paper industry wastewater emissions would need to be identified to estimate pre-2003 emissions.

Production data for calculating wastewater emissions for the poultry sector were compiled for broiler chickens and turkeys from the USDA's NASS. These data were cross-referenced with production data for commercial broilers and turkeys from the 2022 NC Agricultural Statistics.[31]

1.10.4. Future Refinements

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[29] *EPA. "User's Guide for Estimating Emissions from Wastewater Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.*

[30] *USDA. "National Agricultural Statistics Service, Quick Stats." https://quickstats.nass.usda.gov/.*

[31] *USDA. "2022 NC Agricultural Statistics." https://www.nass.usda.gov/Statistics_by_State/North_Carolina/Publications/Annual_Statistical_Bulletin/index.php. Accessed December 2023.*

NC-specific red meat production data and fruit and vegetable production data would enhance the emission estimates for this module if such data could be identified.

For consistency with other modules, NC OSBM population data could be used instead of the default population values if the SIT would allow replacement of the Wastewater module's default population data.

1.11. Industrial Processes

1.11.1. Description

The Industrial Processes module of the SIT calculates GHG emissions as follows:

- CO_2 emissions from cement production, lime manufacture, limestone and dolomite use, soda ash manufacture and consumption, iron and steel production, and ammonia manufacture.
- CO_2 and PFC emissions from aluminum production.
- N_2O emissions from nitric acid production and adipic acid production; and
- HFC, PFC, nitrogen trifluoride (NF_3), and SF_6 from HCFC-22 production, consumption of substitutes for Ozone-Depleting Substances (ODS), semiconductor manufacture, electricity transmission and distribution, and magnesium production and processing.

1.11.2. Background and Defaults

The methodology for estimating GHG emissions from Industrial Processes is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[32] The methodology in the Industrial Processes module varies by sector so each sector is discussed separately with specific examples in the SIT's User Guide.

NC does not have the following Industrial Processes operating in the State: cement production; lime manufacture; ammonia manufacture; nitric acid production; adipic acid production; magnesium production; and HCFC-22 production.

Consumption of ODS substitutes reflects national emissions allocated to each state. National emissions are apportioned to each state using a hybrid approach, based on both population and regional emission estimates from specific HFCs. Regional HFC emission estimates were provided by Hu, L., et al. (2017).[33]

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[32] EPA. "User's Guide for Estimating Emissions from Industrial Processes Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.

[33] Hu, L., et al., "Considerable contribution of the Montreal Protocol to declining greenhouse gas emissions from the United States," Geophys. Res. Lett., 44, 8075–8083, 2017.

1.11.3. Deviations from Defaults

Iron and steel production and semiconductor manufacture are the only sectors in the Industrial Processes module where estimates deviated from SIT defaults. The default values for the Iron and Steel Production sector are based on national averages and appeared to overestimate emissions in NC. There is only one permitted facility in NC that operates using a production method listed in the SIT. Therefore, production/activity data from the DAQ's IBEAM-ED module for that permitted facility were converted to MT. These values were entered into the SIT for calendar years 2001 to 2020.

Semiconductor manufacture GHG estimates for calendar years 1990 through 2015 were calculated using SIT defaults. In the SIT, default estimates of national emissions from the semiconductor manufacturing sector are distributed to NC based on the ratio of the monetary value of NC semiconductor shipments to the value of national semiconductor shipments. For the years available (2016 through 2020), NC semiconductor manufacturer emissions of SF_6, HFC, NF_3, and PFC were obtained directly from the GHG Reporting Program. All three NC permitted facilities in the semiconductor manufacturer sector reported emissions to the GHG Reporting Program, so these emissions were summed and entered into the SIT for each calendar year.

Phosphoric acid production is not included in the SIT Industrial Processes module; however, NC emissions data are reported for this process to EPA's GHG Reporting Program. Because NC has one phosphoric acid production facility that reports emissions to EPA, the DAQ added these emissions for the years for which they were available (2010 through 2020). Calendar year 2002-2009 emissions were estimated using data reported to the DAQ, current carbon weight percent values obtained from the facility, and the calculation equation Z-1A in Part 98 Subpart Z of the Federal Mandatory GHG Reporting Rule. No throughput data or weight percent of carbon are readily available for calendar years 1990 through 2001, therefore, the 2002 CO_2 emission value is reported for these years as a best estimate.

1.11.4. Future Refinements

For the two sectors that use national emissions, consumption of ODS substitutes and semiconductor manufacturing, the SIT default population values for NC from 1990 to 2020 were used because these tables are protected and could not be accessed. For consistency with other modules, the NC OSBM's population data could be used for the allocation process instead of the default population values.

The ODS substitutes sector is the largest contributor to PFC, HFC, and SF_6 emissions for NC. A more in-depth review of the calculation methodology for this sector may be warranted because the projected values for this sector reflect a significantly large increase.

1.12. Land Use, Land Use Change, and Forestry

1.12.1. Description

The LULUCF sector accounts for emissions and/or sequestration of CO_2, CH_4, and N_2O from activities on NWL. These are broken down into subsectors by major land use type, including Forest Lands; Cropland and Grassland; Settlements; and Wetlands. The source of best-available estimates varies by subsector and category, which are summarized in Table A-1 below.

GHG inventories report fluxes occurring within each land use type, as well as those resulting from conversions between land use types. A land use change refers to land converted to a different use within the previous 20 years. This inventory follows the structure of the EPA GHGI, which groups sources of emissions and sinks by current land use category.

Table A-1. Source of LULUCF Sector Emissions/Sink Estimate by Subsector/Category

Data Source/Subsector	Category
SIT Module	
Forest Lands	Forest Carbon Flux* Non-CO_2 Emissions from Forest Fires**
Cropland and Grassland	Agricultural Soil Carbon
Settlements	N_2O on Settlement Soils
EPA Greenhouse Gas Inventory for NC	
Settlements***	SRS: Urban Trees SRS: Landfilled Yard Trimmings and Food Scraps LCS: Ecosystem Carbon SRS: Organic Soil
Wetlands	Flooded Lands and Peatlands
NC Coastal Habitats Greenhouse Gas Workgroup	
Wetlands	Coastal Wetlands

* Forest Land Remaining Forest Land and Land Converted to Forest Land. Forest Carbon Flux in the SIT also includes Forest Land Converted to Settlements, see text for details.

** SIT with acreage burned data compiled from NC and federal databases, see text for details.

*** Settlements Categories: Settlements Remaining Settlements (SRS) and Land Converted to Settlements (LCS)

Since the 2022 NC GHG Inventory, EPA has updated data and/or methods in every LULUCF subsector. As a result, some estimates in this report are substantially different from those reported in the 2022 inventory. The LULUCF SIT module includes default data from the USFS and the GHGI for Forest Lands; Cropland and Grassland; and some categories within the Settlements subsector. The GHGI also includes updates to some data sources and/or methodologies which EPA has not yet integrated into the SIT.[34] As with the previous (2022) GHG inventory, this inventory includes EPA estimates of NC emissions/sinks for some Settlements and Wetlands categories missing from the SIT. The DAQ incorporated the EPA state-level estimates for these missing source categories in this inventory and incorporated the updated estimates for other source categories. Estimates used in this inventory for Coastal Wetlands were developed by the NC Coastal Habitats Greenhouse Gas Workgroup.[35]

1.12.2. Background and Defaults

The methodologies used within the SIT for estimating CO_2, CH_4, and N_2O emissions from the LULUCF sector are provided in the User's Guide as well as instructions and information in the spreadsheets of the LULUCF module.[36] The default input data within the SIT are revised periodically to reflect the latest data sources and methodologies, though these updates may not be completed at the same intervals as updates incorporated into EPA's GHGI. The DAQ used the SIT's LULUCF module and default inputs to develop estimates for Forest Carbon Flux (FRF and *Land Converted to Forest Land)*, non-CO_2 emissions from Forest Fires, Agricultural Soil Carbon Flux, and N_2O emissions from fertilization of Settlement Soils. The inputs varied considerably from category to category but included estimates of carbon stock changes in forests, wood products, and agricultural soils, and the amount of synthetic fertilizer applied to soil on developed lands. Carbon dioxide emissions from forest fires are automatically accounted for in the SIT's inventory of forest carbon stocks, and non-CO_2 emissions from forest fires are estimated separately in the SIT. Significant changes to estimates of carbon flux in the forest and agriculture subsectors reflect EPA's updates to the SIT default data since the previous (2022) GHG inventory.

1.12.3. Deviations from Defaults

Forest Fires

Emissions of CH_4 and N_2O from forest fires are estimated in the SIT module, requiring inputs of annual area burned. No single source of acreage burned data is available for all

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[34] EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2020." April 2022. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.

[35] NC Coastal Habitats GHG Workgroup. "NC Coastal Habitat Greenhouse Gas Inventory." September 2023.

[36] EPA. "User's Guide for Estimating Emissions and Sinks from Land Use, Land-Use Change, and Forestry Using the State Inventory Tool." Prepared for EPA's State Energy and Environment Program by ICF, June 2023.

inventory years, and some sources only report data for certain fire types or jurisdictions. To compile forest fire acreage burned data, the DAQ used a combination of approaches and the best-available data sources for each year, consistent with the methods in the previous (2022) NC GHG inventory.

The acreage burned estimates developed for this inventory prioritized wildfire data from the NCFS, supplemented by the federal interagency "SIT-209" database for wildfires and prescribed burning.[37,38] Because data were not accessible from the SIT-209 for every year, the DAQ used other methods/data to estimate values in some (mostly earlier) years. Sources included the National Interagency Fire Center and the EPA's National Emissions Inventory.[39,40] The DAQ is working to identify additional sources of burn acreage data to refine these estimates for future versions of NC's inventory.

Settlements

Three Settlements categories are included in the SIT's LULUCF module. Emissions of N_2O from Settlement Soils were modeled in the SIT using default data. Estimates for carbon stock changes in both the Urban Trees and Landfilled Yard Trimmings and Food Scraps categories differed significantly between the EPA's GHGI and the SIT. In communication with EPA, it was determined that the GHGI estimates were developed using the latest data and methods and are a better representation of NC's carbon sequestration in these categories. Therefore, the DAQ incorporated carbon flux estimates from the 1990-2020 GHGI into this inventory for these categories.

The GHGI also provides estimates for other Settlements categories not included in the SIT. To provide a comprehensive LULUCF sector inventory, the previous NC GHG Inventory supplemented SIT Settlements estimates with additional GHGI Settlements estimates. In the previous NC inventory, GHGI estimates for Land Converted to Settlements (LCS) – *Changes in Ecosystem Carbon Stocks* were incorporated into a category listed as "Categories not included in SIT." At that time, it was not clear that Forest Land Converted to Settlements (FCS) was also included in the SIT's Forest Carbon Flux subsector. The SIT/GHGI overlap is demonstrated in Table A-2 showing LCS estimates by carbon pool from both the SIT (which only includes FCS) and the GHGI (which includes all land use types converted to settlements). The SIT and GHGI estimates for living biomass and dead plant matter are an exact match, because those LCS carbon pools only apply to FCS. SIT data includes estimates

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[37] *NCFS. "Wildfire and Acreage Statistics: 1928- Present." https://www.ncforestservice.gov/fire_control/wildfire_statistics.htm. Accessed November 2023.*

[38] *U.S. Department of Agriculture and the U.S. Department of the Interior. SIT-209 data obtained from Wildland Fire Application Information Portal: https://www.wildfire.gov/application/sit209. Accessed October 2023.*

[39] *U.S. Department of Interior, National Interagency Fire Center. Historical year-end fire statistics by state compiled from National Interagency Coordination Center fire records. https://www.nifc.gov/nicc/predictive-services/intelligence.*

[40] *EPA. "Pollutant Emissions Summary Files for Earlier NEIs." https://www.epa.gov/air-emissions-inventories/pollutant-emissions-summary-files-earlier-neis. Accessed February 2021.*

for mineral soils in FCS, and GHGI includes those FCS mineral soil estimates as well as mineral and organic soil estimates for other land use types converted to settlements.

Table A-2. LCS Emissions Estimates by Data Source ($MMTCO_2e$)

	1990		2005		2020	
LCS* Carbon Pools	**SIT (only FCS**)**	**GHGI (all LCS)**	**SIT (only FCS)**	**GHGI (all LCS)**	**SIT (only FCS)**	**GHGI (all LCS)**
Aboveground Biomass	1.75	1.75	1.81	1.81	1.85	1.85
Belowground Biomass	0.34	0.34	0.35	0.35	0.36	0.36
Deadwood	0.23	0.23	0.24	0.24	0.24	0.24
Litter	0.41	0.41	0.42	0.42	0.43	0.43
Soil (Mineral)	0.04	0.23	0.07	0.65	0.05	0.41
Soil (Organic)	-	0.05	-	0.08	-	0.03
Total LCS	**2.77**	**3.00**	**2.89**	**3.55**	**2.93**	**3.32**
Non-forest LCS		0.23		0.66		0.39

* Land Converted to Settlements

** Forest Land Converted to Settlements

Because this NC Inventory follows the GHGI's category structure, LCS emissions are reported within the Settlements subsector. The GHGI estimates for LCS, which include all land use types converted to settlements (including FCS), are incorporated into this inventory as LCS: *Ecosystem Carbon Flux*. The removal of previously double-counted FCS estimates results in significantly lower LCS estimates in the current inventory. The correction, summarized in Table A-3 results in lower emissions by about 3 MMT.

The EPA's GHGI estimates for Settlements Remaining Settlements – *Organic Soil Carbon Flux* are also incorporated into this NC inventory.

Table A-3. LCS Emissions Estimates by Inventory Year ($MMTCO_2e$)

Report year/ Subsector	Category/ Subcategory/ Data Source	1990	2005	2010	2015	2018	Average 2005-2018
2022	**Total LCS Reported**	**5.92**	**6.57**	**6.47**	**6.40**	**6.35**	**6.46**
Forest Carbon Flux	FCS from SIT	2.84	2.94	2.95	2.98	2.97	
Categories not included in SIT	LCS from GHGI	3.08	3.64	3.52	3.42	3.38	
2024 Settlements	**Total LCS from GHGI**	**3.00**	**3.55**	**3.43**	**3.35**	**3.32**	**3.42**
Average Difference							-3.04

Wetlands

The Wetlands subsector includes emissions/sequestration estimates for Peatlands, Flooded Lands, and Coastal Wetlands. The GHGI includes estimates for Wetlands subcategories related to Peatlands and Flooded Lands.[41] Three new GHGI subcategories are incorporated into this updated NC inventory: Land Converted to Wetlands – *Changes in Carbon Stocks in Lands Converted to Flooded Lands*, Wetlands Remaining Wetlands – *Flooded Lands Remaining Flooded Lands* (CH_4), and Land Converted to Wetlands – *Land Converted to Flooded Lands* (CH_4).

In 2023, the NC Coastal Habitats Greenhouse Gas Workgroup (Workgroup), formed within the NC Natural and Working Lands Stakeholder Group, developed a new inventory of GHG emissions/sinks from land converted to/remaining coastal wetlands.[42] In order to refine estimates for NC, the Workgroup utilized high-resolution federal land use and land cover data for coastal wetlands that have not yet been integrated into the SIT or GHGI methodologies. The DAQ has incorporated Workgroup estimates for estuarine coastal wetlands (salinity ≥ 0.5 practical salinity units) into this inventory. The Workgroup also developed estimates of GHG emissions and removals within high-salinity seagrass meadows, which are not inventoried in any EPA inventory. The Workgroup's seagrass estimates are included as a new subcategory in this inventory. NC's Coastal Wetlands are a net GHG emitter, but at a very small scale relative to the overall LULUCF Sector. Table A-4 shows Coastal Wetlands emissions and sinks by gas and category in kilotons (kt) CO_2e (1

[41] *EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks by State: 1990-2020." April 2022.* https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.

[42] *NC Coastal Habitats GHG Workgroup. "NC Coastal Habitat Greenhouse Gas Inventory." September 2023.*

MMT = 1,000 kt). The estimates reflect a decrease in both annual carbon sequestered and annual emissions from Coastal Wetlands between 2005 and 2020. For 2020, net Coastal Wetlands flux was estimated at 34.1 kiloton of carbon dioxide equivalent (kt CO_2e) (0.034 $MMTCO_2e$).

Carbon sequestered in high-salinity seagrass meadows has decreased over time due to a loss in coverage area. The Workgroup expects that this trend will continue over the coming decades and has projected acreage and emissions for 2030 and 2050 as shown in Table A-5 below.[43] Because of their small magnitude and the uncertainty surrounding these projected emission changes, this projection is not incorporated into the LULUCF sector forecast for the state.

Table A-4. GHG Emissions and Sinks from Coastal Wetlands (kt CO2e)

Gas/Category	1990	2005	2017	2018	2019	2020
CO_2						
Coastal Wetlands Remaining Vegetated Coastal Wetlands	-276.03	-270.57	-279.91	-278.58	-277.25	-275.92
Land Converted to Vegetated Coastal Wetlands	-2.58	-1.24	-2.07	-2.09	-2.11	-2.14
Seagrass Soil Carbon Flux	-70.46	-70.46	-60.53	-59.18	-57.83	-56.49
Coastal Wetlands Carbon Flux	-349.08	-342.27	-342.51	-339.86	-337.20	-334.54
CH_4						
Coastal Wetlands Remaining Vegetated Coastal Wetlands	373.29	382.31	373.25	371.32	369.38	367.44
Land Converted to Vegetated Coastal Wetlands	0.07	0.07	0.86	0.97	1.08	1.19
Coastal Wetlands Emissions	373.37	382.37	374.12	372.29	370.46	368.63
Net GHG Flux (kt CO_2e)	**24.29**	**40.11**	**31.60**	**32.43**	**33.26**	**34.09**

[43] *NC Coastal Habitats GHG Workgroup. "High Salinity Seagrass Meadows: Projections of area and carbon net accumulation to 2030 and 2050." Email transmitted by Workgroup to Amanda Crenshaw, NCDAQ, December 2023.*

Table A-5. Workgroup Projections for Seagrass Area (acres) and Emissions (kt CO_2e)

Seagrass Projections	2020	2030	2050
Area (acres)	88,526	67,383	36,399
Soil Carbon Flux (kt CO_2e)	-56.49	-42.99	-23.22

Planned integration by EPA of coastal land use and land cover datasets into future inventories will result in further refinement of coastal wetlands GHG estimates.

1.13. Inventory and BAU Tables by Sector and Subsector

Table A-6. Multiple GHG Inventory years summarized by subsector and gas ($MMTCO_2e$)

Emissions Source/Sink	2005 Base Year Emissions ($MMTCO_2e$)	Interim Year 1 (2010) ($MMTCO_2e$)	Interim Year 2 (2015) ($MMTCO_2e$)	Most Recent Inventory Year (2020) ($MMTCO_2e$)
Electricity Generation				
CO_2	82.29	82.60	58.34	41.63
CH_4	0.03	0.04	0.04	0.03
N_2O	0.34	0.34	0.20	0.12
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Commercial and Residential Buildings				
CO_2	24.59	21.05	19.86	18.73
CH_4	0.25	0.27	0.20	0.17
N_2O	0.13	0.13	0.12	0.11
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Transportation				
CO_2	57.35	57.32	57.49	49.59
CH_4	0.39	0.32	0.25	0.15
N_2O	0.82	0.81	0.73	0.61
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Agriculture				
CO_2	0.00	0.00	0.00	0.00
CH_4	8.09	7.64	7.41	7.68
N_2O	4.55	4.57	5.14	4.78
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Waste and Materials Management				
CO_2	0.05	0.03	0.04	0.04
CH_4	6.92	7.69	5.68	6.85
N_2O	0.24	0.25	0.27	0.28
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Industry				
CO_2	0.52	0.48	0.48	0.34
CH_4	0.00	0.00	0.00	0.00
N_2O	0.00	0.00	0.00	0.00
HFC, PFC, SF_6	4.36	4.51	6.08	6.88

Natural Gas and Oil Systems				
CO_2	0.00	0.00	0.00	0.00
CH_4	1.53	1.62	1.39	1.48
N_2O	0.00	0.00	0.00	0.00
HFC, PFC, SF_6	0.00	0.00	0.00	0.00
Gross Emissions	**192.45**	**189.67**	**163.72**	**139.47**
Sinks	-45.08	-47.26	-48.29	-47.68
Net Emissions	**147.37**	**142.41**	**115.43**	**91.79**

Table A-7. Expanded Inventory Table by sector and subsector (MMTCO2e)

Sector	Base Year Total Emissions ($MMTCO_2e$)	Inventory Year (2010) Total Emissions ($MMTCO_2e$)	Inventory Year (2015) Total Emissions ($MMTCO_2e$)	Inventory Year (2020) Total Emissions ($MMTCO_2e$)
Electricity Generation and Use	**82.66**	**82.98**	**58.58**	**41.77**
Electricity Generation	75.78	73.32	52.31	37.24
Imported Electricity	6.88	9.66	6.27	4.54
Residential/Commercial/Industrial Combustion	**24.97**	**21.45**	**20.17**	**19.01**
Industrial	13.09	9.73	9.39	9.23
Commercial	5.08	5.13	5.31	4.88
Residential	6.79	6.59	5.47	4.90
Transportation	**58.56**	**58.45**	**58.47**	**50.35**
Gasoline & Diesel Highway	53.78	53.39	52.74	45.45
Non-Highway	4.72	4.95	5.58	4.71
Alternative Fuel Vehicles	0.06	0.10	0.15	0.18
Agriculture	**12.63**	**12.21**	**12.54**	**12.46**
Manure Management	6.58	6.27	6.08	6.49
Agricultural Soil Management	3.95	4.01	4.54	4.12
Enteric Fermentation	2.10	1.93	1.91	1.85
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00
Waste Management	**7.21**	**7.98**	**5.99**	**7.17**
Municipal Solid Waste	5.90	6.48	4.42	5.49
Wastewater	1.31	1.49	1.57	1.69
Industrial Processes	**4.87**	**4.98**	**6.56**	**7.22**
Natural Gas and Oil Systems	**1.53**	**1.62**	**1.39**	**1.48**
Gross Emissions	**192.42**	**189.67**	**163.71**	**139.45**
Sinks	-45.08	-47.26	-48.29	-47.68
Net Emissions	**147.34**	**142.40**	**115.42**	**91.77**

Table A-8. Expanded Inventory of GHG emissions by gas for each sector and subsector for 2020 ($MMTCO_2E$)

Emissions Source/Sink	GHG Emissions by Gas ($MMTCO_2E$)			
	CO_2 (79%)	CH_4 (12%)	N_2O (4%)	HFC, PFC, SF_6, and NF_3 (5%)
Electricity Generation and Use	**33.00**	**5.01**	**1.67**	**2.09**
Electricity Generation	29.42	4.47	1.49	1.86
Imported Electricity	3.59	0.54	0.18	0.23
Residential/Commercial/Industrial Combustion	**15.02**	**2.28**	**0.76**	**0.95**
Industrial	7.29	1.11	0.37	0.46
Commercial	3.86	0.59	0.20	0.24
Residential	3.87	0.59	0.20	0.25
Transportation	**39.78**	**6.04**	**2.01**	**2.52**
Gasoline & Diesel Highway	34.54	5.45	1.82	2.27
Non-Highway	3.58	0.57	0.19	0.24
Alternative Fuel Vehicles	0.14	0.02	0.01	0.01
Agriculture	**9.84**	**1.50**	**0.50**	**0.62**
Manure Management	5.13	0.78	0.26	0.32
Agricultural Soil Management	3.25	0.49	0.16	0.21
Enteric Fermentation	1.46	0.22	0.07	0.09
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00
Waste Management	**5.66**	**0.86**	**0.29**	**0.36**
Municipal Solid Waste	4.34	0.66	0.22	0.27
Wastewater	1.34	0.20	0.10	0.08
Industrial Processes	**5.70**	**0.72**	**0.29**	**0.36**
Natural Gas and Oil Systems	**1.17**	**0.15**	**0.06**	**0.07**
Gross Emissions	**110.33**	**16.36**	**5.90**	**6.88**
Sinks	-37.67	-5.72	-1.91	-2.38
Net Emissions	**72.66**	**10.64**	**3.99**	**4.50**

1.13.1. Future Refinements

The EPA releases annual state-level estimates of emissions/sinks for the LULUCF sector as part of its state GHGI. For several subsectors, these data have matched the default data in the SIT module. Where the estimates differed between the two sources, DAQ made the determination of which data to include in this inventory through communication with EPA. The DAQ anticipates that future LULUCF sector estimates from EPA will be more closely aligned between the two sources. For those LULUCF sector subcategories that are not estimated in the SIT, EPA's state-level emission/sink estimates are incorporated into NC's inventory. The notable exceptions are coastal wetlands subcategories, which are taken from the NC Coastal Habitats Greenhouse Gas Inventory. Future versions of the LULUCF sector inventory will incorporate emissions/carbon flux estimates reflecting the best information available at that time.

Harvested Wood Products (HWP) are a component of Forest Carbon Flux, estimating carbon sequestered in trees that are cut for wood products such as building materials, furniture, or paper. The EPA and USFS are working to develop refined state-level estimates of carbon flux in HWP. These estimates are of particular interest in NC, where forestry and HWP manufacturing are among the state's largest industries. The DAQ anticipates that more accurate assessments of carbon stored in wood products will be available for inclusion in future versions of NC's inventory.

An expert panel exploring the carbon sequestration potential of NC's NWL found that restoration of peatlands may have the potential to convert them into a net sink, as well as building resilience to fire and creating broad ecosystem benefits.[44] Further study, including data from restoration projects, may allow development of sequestration estimates in NC peatlands for future inventories.

1.14.

1.15. Projected GHG Emissions (2021-2050) – e.g. Business As Usual (BAU)

1.15.1. Description

Because of delays in preparing and releasing historical data by various government agencies, 2020 is generally the last year for which historical data are used in estimating NC's GHG emissions. This section summarizes the methods and data sources that are used to project the 2020 emissions from 2021 through 2050. These projections represent a characterization of future emissions based on information available at the time of this

[44] *"NC Climate Risk Assessment and Resilience Plan: Appendix B: North Carolina Natural and Working Lands Action Plan." June 2020.*

study and only reflect the effects of "on-the-books" measures to limit GHG emissions where information is available to characterize their effects.

1.15.2. Background and Defaults

Emissions forecasts are generally developed using the Projections Tool module within EPA's SIT. The Projections Tool has 18 sub-modules for estimating source sector emissions using different default data and forecasting techniques for each sector. The methodologies incorporated into the Projections Tool are summarized in the User's Guide for this module, as well as instructions and information provided in the spreadsheets for each module subsector.[45]

This module forecasts emissions for each source sector using one of the following approaches.

(1) Projections of emissions activity such as fuel use or number of livestock or surrogates for such activity (e.g., human population is used to develop state-level projections from national forecasts).
(2) Extrapolation of historical trends in emissions or emissions activity.

The following table summarizes the default projection methodology for each source sector.

Table A-9. Projection Methods for Each Source Sector

Forecast Based on Projections Data	Forecast Based on Historical Trend
Electric Generation and Consumption*	Agricultural Soils
RCI Combustion*	Agricultural Residue Burning
Transportation/Mobile Source Combustion	Waste Combustion
ODS Substitutes; Electric Power Systems	Industrial Processes (except subsectors at left)
Solid Waste Management	Wastewater
Livestock	
Natural Gas Systems	

*Excludes wood. Wood consumption is based on the historical trend in fuel consumption.

For sectors that forecast emissions based on projections data, the tool relies on projections of activity data (or surrogate activity data) obtained from similar federal and state resources as those used in calculating historical emissions.

[45] *EPA. "User's Guide for States Using the Greenhouse Gas Projection Tool." Prepared for EPA's State Energy Program by ICF, June 2023.*

Note that the Projections Tool does not have a sub-module for the LULUCF sector, therefore, the 2020-year estimates for GHG emissions and carbon sinks are generally carried forward to each forecast year (the one exception, as discussed below, is the Forest Fires category).

1.15.3. Deviations from Defaults

In some cases, different projections methods/data are used to estimate emissions than the default methods/data provided in EPA's Projections Tool. These revisions reflect the use of more current data, NC-specific data, or a methodology that results in projected emissions better in line with NC historical trends. The revisions to the use of Tool defaults are summarized in Table A-7. In addition to the revisions listed in this table, the Tool default population projections are replaced with projections from the NC OSBM.[46]

Table A-10. Summary of Revisions to EPA Projections Tool Defaults

Sector	Revised Projections Approach(es)	Rationale for Use
Electricity Generation and Imported Electricity	Electricity Generation For 2021 & 2022, heat input (in MMBtu) by fuel type from fuel used in 2021 & 2022, which was obtained from EIA Form 923 data.[47] For 2023 through 2050 heat input, two different approaches are used: (a) For Duke Energy facilities: 2024 through 2050 - Duke Energy Corporation's October 2023 Pathway 1/ Core Portfolio 1 forecast of NC fuel use (in MMBtu).[48] For 2023, values interpolated between actual 2022 EIA fuel input and Duke Energy's 2024 forecast fuel use.	Historical fuel use data are preferable to a projection. Duke Energy's forecast is preferred because it is developed via the Integrated Resource Plan process. 2023 interpolated values are used

[46] *NC Office of State Budget and Management. "County/State Population Projections." https://www.osbm.nc.gov/facts-figures/population-demographics/state-demographer/countystate-population-projections. Accessed November 2023.*

[47] *EIA. "2020-2022 Form EIA-923 detailed data with previous form data (EIA-906/920)." https://www.eia.gov/electricity/data/eia923/. Accessed July 2023.*

[48] *Duke Energy, 2023 CPIRP NCDAQ Data Request – P1.xlsx, e-mail transmittal from Cynthia Winston to Ming Xie, NC Division of Air Quality, October 11, 2023.*

Sector	Revised Projections Approach(es)	Rationale for Use
	(b) All other NC electricity generation reflect the average of the last three available years (2020-2022) of fuel consumption (in MMBtu) compiled from EIA Form 923 data. Imported Electricity (a) For 2021-2050, SIT projections of retail electricity consumption are used. (b) The percent of imported electricity for all projection years is assumed to be the average of the percent imported over the last three (2019-2021) available years (11.22%) based on EIA data.[49] (c) The imported electricity used for a given year is calculated as the projected retail electricity consumption multiplied by the percent imported. (d) Projected GHG emission rates are based on information provided in a recent EPA regulatory impact analysis.[50]	because 2023 actual values are not yet available. The historical average fuel use is used because these sources represent a small percentage of sector emissions and forecasts for all these smaller sources are not available. Imported electricity emissions were calculated using the most recent data available for characterizing net imports (2019-2021). This value was held constant for projection years since there are many uncertainties in projecting imported electricity. Projected rates for South Carolina are the highest of the rates of adjoining states, so represent a conservative assumption.

[49] *EIA, State Energy Data System (SEDS): 1960-2021, available from https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption, accessed September 2023.*

[50] *EPA, "Regulatory Impact Analysis for the Proposed New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule," EPA-452/R-23-006, May 2023.*

Sector	Revised Projections Approach(es)	Rationale for Use
Transportation	*Onroad Vehicles* – MOVES4 model runs with NC historical/forecast VMT inputs used to estimate 2021, 2030, and 2050 emissions. Emissions for 2022-2029 estimated as product of VMT and emission factors interpolated from 2021 and 2030 MOVES4 model run output. Emissions for 2031-2049 estimated similarly from 2030 and 2050 MOVES4 model run output. *Non-highway* – Aviation and Boats use a linear extrapolation of historical emissions data. Locomotives, Farm Equipment, Construction Equipment, and Other Equipment apply the average of 2003-2020 emissions in each category and apply this value to each forecast year.	A more sophisticated modeling approach that uses official EPA onroad mobile source emissions estimation model, provides additional subsector granularity, and future year modeling flexibility. Forecast emission trends were not in line with historical trends. Forecast approach based on historical emissions trend – if there is a clear trend (Aviation/Boats) or not (all other categories). With Aviation and Boats, a clear trend only started with 2003 emissions (probably due to post-9/11 travel/economic impacts), so pre-2003 data were excluded from use in each forecast approach.
Industrial Processes	*ODS substitutes* – apply HFC emissions growth rates from national EPA non-CO_2 projections report to 2020 NC emissions.[51] *Phosphoric acid production* is not included in the SIT Industrial	Default Tool projections result in emission values that are unrealistically high. Reported GHG emissions from phosphoric acid production are relatively constant from 2002.

[51] *EPA, "Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation, 2015–2050," Office of Atmospheric Programs, EPA-430-R-19-010, October 2019.*

Sector	Revised Projections Approach(es)	Rationale for Use
	Processes module; however, NC emissions data are reported for this process to EPA's GHG Reporting Program. The 2021 CO_2e value is carried forward every year to 2050.	through 2016, so the 2016 value is held constant for projected years.
Solid Waste/Landfill CH_4 Emissions	Apply average of 2003-2020 emissions to each forecast year.	Best identified approach given historical emissions did not indicate a clear trend (periods with increases and periods with decreases), while the SIT Projection Tool consistently forecast unrealistically large emissions increases.
Land Use/Forest Fires	Forest Fire emissions held constant at the 10-year average for 2011-2020.	Emissions from wildfires and prescribed burns are highly variable. Recent longer-term values capture high, medium, and low occurrence years related to shorter-term climate interactions with normal seasonal trends.

Electricity Generation

To incorporate an initial estimate of the impact associated with the 2030 and 2050 CO_2 emissions reduction targets established in SL 2021-165, the emissions forecast for the electricity generation sector in this report incorporates the generation forecast for Pathway 1/Core Portfolio 1 Duke Energy included in its proposed Carbon Plan/Integrated Resources Plan (CPIRP) submitted to the NCUC on August 17, 2023.[52]

For use in this Electricity Generation forecast, the DAQ summed Duke Energy's proposed Pathway 1/Core Portfolio 1 unit-level fuel use (i.e., heat input) projections by fuel type for each year from 2024 through 2050. These projections were used along with the SIT's Projection Tool fuel-specific emission factors to project GHG emissions for Duke Energy facilities for these years. Because actual 2021 and 2022 heat input by fuel type was available from EIA for Duke Energy facilities, these data were used to develop emission projections for these years. Because 2023 heat input data were not available at the time

[52] *Duke Energy, 2023 CPIRP NCDAQ Data Request - P1.xlsx, e-mail transmittal from Cynthia Winston to Ming Xie, NC Division of Air Quality, October 11, 2023.*

that this forecast was produced, the DAQ interpolated between the actual 2022 heat input by fuel type and the 2024 proposed CPIRP Pathway 1 fuel type projections to estimate 2023 fuel use for Duke Energy units. The fuel use estimates for Duke Energy for 2021-2023 were combined with the SIT Projection Tool's fuel-specific emission factors to estimate emissions in these years.

For non-Duke Energy units in NC, emission projections reflect use of the Tool's emission factors and the average of the last three available years of fuel consumption data (2020-2022), compiled from the EIA.[53] This approach is consistent with that used in the previous GHG inventory, and reflects the lack of information for projecting fuel use/emissions for these generating units.

The DAQ applied the same approach to estimating net interstate flow of electricity for NC as was used in the previous GHG inventory. This approach relies on electricity demand forecasts for NC from EPA's Projections Tool, and the recent historical average percentage of NC demand met by imports (approximately 11% for 2019-2021). To estimate future year imported electricity CO_2 emission factors per kilowatt-hour (kWh), the DAQ applied the emission rates projected for South Carolina from EPA's regulatory impact analysis for its proposed New Source Performance Standards/Emission Guidelines for GHGs from Electric Generating Units.[54] Because EPA did not develop CH_4 and N_2O emission projections in this regulatory analysis, the DAQ calculated forecast year CH_4 and N_2O emission rates by first calculating ratios of the projected South Carolina CO_2 emission rate in each forecast year to the 2021 CO_2 emission rate. The DAQ then applied these ratios to 2021 CH_4 and N_2O emission rates to develop projected CH_4 and N_2O emission rates for imported electricity.

Onroad Vehicles

Forecasts for the onroad vehicle sector were developed from a 2021 emissions baseline. For the 2021 GHG onroad emissions modeling, the DAQ used 2021 VMT estimates from the NCDOT based on the data compiled for the HPMS. For the 2030 and 2050 onroad vehicle GHG emissions modeling, the DAQ used VMT estimates projected from the 2022 NC HPMS VMT dataset. County-level growth factors for 2023 through 2050, relative to a 2022 base year, were first developed based on population forecasts for each NC county obtained from the NC OSBM State Demographer's Office and on annual per capita VMT forecasts obtained from Annual Energy Outlook (AEO) 2023. The DAQ then developed 2030-year and

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[53] EIA, "2020-2022 Form EIA-923 detailed data with previous form data (EIA-906/920)," available from https://www.eia.gov/electricity/data/eia923/, accessed July 2023.

[54] EPA. "Regulatory Impact Analysis for the Proposed New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule," EPA-452/R-23-006. May 2023.

2050-year county-level VMT projections by multiplying each county's 2022 annual VMT by their corresponding 2030 and 2050 growth factors.

To evaluate the impact of battery electric vehicles (BEVs) on future GHG emissions, estimates of VMT by vehicle type and fuel type were developed for 2021, 2030, and 2050 from MOVES4 model runs using statewide vehicle fleet and VMT estimates for each year. The output data, which reflected the MOVES4 default fractions of BEVs in the fleet, were compiled to provide statewide annual VMT estimates by vehicle type and fuel type. Estimates of 2030 and 2050 fleet populations of light-, medium-, and heavy-duty BEVs were then developed for the Duke Energy service areas of the state (roughly 83 counties) and were extended to cover the remaining 17 counties serviced by other utilities. Duke Energy provided projected annual numbers of light-, medium-, and heavy-duty BEVs in operation within the Duke Energy service areas for the years 2023 through 2040, consistent with its corresponding projections for BEV-related energy generation.[55] Based on these data, the DAQ developed estimates of BEVs in service for years 2041-2050. The DAQ then used the 2030 and 2050 BEV population estimates to revise the distribution, by vehicle type and fuel type, of the 2030 and 2050 statewide VMT estimates, assuming that BEVs would be one-to-one replacements of light-, medium-, and heavy-duty internal combustion engine vehicles. Under this assumption, each BEV introduced into the fleet effectively zeroes out the GHG emissions from an internal combustion engine vehicle of the same type. This provided 2030 and 2050 VMT estimates consistent with the Duke Energy BEV projections.

To generate statewide GHG onroad mobile source emission factors, MOVES4 modeling runs, using the model default inputs data for NC, were completed for 2021, 2030, and 2050. GHG emission factors, in units of grams per mile, were calculated for each vehicle type and fuel type combination. GHG emissions for each year were calculated by multiplying the annual VMT estimates described above by the corresponding emission factors to provide annual grams per year emissions by vehicle type and fuel type, and then converted to annual MT.

Projected onroad emission estimates for each interim year between the modeled years (2021-2029 and 2031-2049) were developed by first interpolating VMT estimates and emission factors between adjacent modeled years (2021-2030 and 2030-2050) and then multiplying the values as described above. Combined with the modeled years, this provided GHG emissions by vehicle/fuel type for each of the three GHGs for all years from 2021 through 2050.

Ozone-Depleting Substances (ODS)

Although there are some other ODS substitutes, HFCs are by far the most prevalent. The EPA has been working to implement the American Innovation and Manufacturing (AIM) Act,

[55] Winston, Cynthia, Duke Energy Corporation, "NC EV Forecast," transmitted to Andy Bollman, NCDEQ, October 23, 2023.

which authorizes EPA to reduce production and consumption of HFCs on the same schedule as the Kigali Amendment, which the U.S. recently ratified. The EPA has begun evaluating the impacts on HFC emissions from the AIM Act, but information is not currently sufficient for use in forecasting emissions from ODS substitutes in NC. Therefore, the DAQ applied growth rates reflecting national HFC emission projections developed by EPA in 2019 to forecast this category (this approach was deemed reasonable when described with an EPA ODS substitute contact).[56] While these projections account for other ODS substance reducing policies (e.g., EPA's Significant New Alternatives Policy Program), they do not account for AIM Act-related emission reductions. Therefore, the projections for this category should be considered conservatively high. Future support from EPA will be essential in developing state-level ODS substitute projections reflecting the AIM Act.

[56] EPA, "Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation, 2015–2050," Office of Atmospheric Programs, EPA-430-R-19-010, October 2019.

Table A-11. Expanded BAU projections by sector and subsector ($MMTCO_2e$)

Sector	Base Year Total Emissions ($MMTCO_2e$)	Inventory Year (2020) Total Emissions ($MMTCO_2e$)	Short-Term BAU Projection Year 2030 (MMTCO2e)	Long-Term BAU Projection Year 2050 (MMTCO2e)
Electricity Generation and Use	**82.66**	**41.77**	**26.71**	**8.50**
Electricity Generation	75.78	37.24	24.00	7.12
Imported Electricity	6.88	4.54	2.70	1.38
Residential/Commercial/Industrial Combustion	**24.97**	**19.01**	**21.14**	**22.69**
Industrial	13.09	9.23	10.43	11.51
Commercial	5.08	4.88	5.59	6.20
Residential	6.79	4.90	5.13	4.98
Transportation	**58.56**	**50.35**	**52.07**	**35.84**
Gasoline & Diesel Highway	53.78	45.45	44.95	26.84
Non-Highway	4.72	4.71	6.79	8.70
Alternative Fuel Vehicles	0.06	0.18	0.34	0.29
Agriculture	**12.63**	**12.46**	**12.46**	**13.28**
Manure Management	6.58	6.49	6.58	7.61
Agricultural Soil Management	3.95	4.12	4.16	4.01
Enteric Fermentation	2.10	1.85	1.71	1.66
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00
Waste Management	**7.21**	**7.17**	**7.48**	**7.99**
Municipal Solid Waste	5.90	5.49	5.50	5.48
Wastewater	1.31	1.69	1.98	2.52
Industrial Processes	**4.87**	**7.22**	**9.00**	**10.12**
Natural Gas and Oil Systems	**1.53**	**1.48**	**1.65**	**1.65**
Gross Emissions	**192.42**	**139.45**	**130.51**	**100.07**
Sinks	-45.08	-47.68	-47.23	-47.23
Net Emissions	**147.34**	**91.77**	**83.28**	**52.84**

1.15.4. Future Refinements

Additional research may identify improved forecast data/methods for sectors for which projections are based on historical trends. It is also important to keep current with the regulatory landscape and determine when the existing projections no longer reflect current standards. For example, the EPA is planning to finalize MHD vehicle CAFE/GHG emissions standards later this year. In addition, projections for a few subsectors are based on EPA national forecasts from many years ago (e.g., the ODS substitute projections are from a 2019 report). The EPA information used to project emissions for this inventory does not account for the impacts of the IRA and IIJA. As these statutes become more fully implemented, it is expected that EPA will release projection information and tools for estimating their associated GHG reductions.[57] Future versions of this inventory will utilize the most recent available forecast data at the time that the inventory is prepared. Finally, it is good practice to review the accuracy of these projections as historical data become available, and to incorporate any lessons learned in preparing future GHG forecasts.

1.15.5. Uncertainty

In keeping with our approach of using the SIT for developing historical emissions estimates, the DAQ generally relied on the SIT's Projection Tool to forecast emissions over the 2019-2050 period (major exceptions are use of Duke Energy heat input forecasts for electricity generation and MOVES4-based emissions forecasts for onroad vehicles). In cases where more state-specific and/or recent data were identified than provided in the SIT, the DAQ replaced default values with these more representative data.

There is associated uncertainty with the forecast capability of the SIT and MOVES4, use of potentially outdated default data, and inherent uncertainty of future GHG policy changes. The DAQ emphasizes our commitment to review the validity of the GHG projections methods used in this effort when undertaking future GHG inventory efforts.

[57] *The DAQ has incorporated Duke Energy's heat input and electric vehicle projections reflecting their modeling of the estimated impacts of IRA. We anticipate that these projections will be further refined in the future by Duke Energy as additional IRA and IIJA program information becomes available.*

Appendix B. Natural Working Lands Background

This appendix contains background information about Sector 6. Natural Working Lands.

1.1. Measure 13. Coastal Protection and Restoration

1.1.1. Measure 13-1. Coastal Habitat Enhancement Initiative

Background and Status in NC

North Carolina is home to the largest estuarine system of any single Atlantic coast state, with approximately 2.2 million acres of estuarine waters, including approximately 100,000 acres of seagrass and 228,000 acres of salt marsh.

North Carolina's Coastal Habitat Protection Plan (CHPP) identifies the primary threats facing seagrass as decreased water clarity and increasing water temperatures and identifies the primary threats facing salt marshes as sea level rise and erosion. Seagrass in NC has been in decline for decades, and as water temperatures continue to increase due to climate change and water clarity suffers due to increased development. Salt marshes are on the front lines of sea-level rise (SLR), and losses of salt marsh are forecast to rapidly accelerate as the rate of sea level rise increases. Sea level rise will also result in salt marshes migrating inland into low-lying uplands as they are inundated by rising water levels, colloquially termed marsh migration corridors (CHPP, 2016.)

1.5ft of SLR is the most likely 2050 SLR scenario for NC, as identified by the 2022 NOAA SLR Technical Report. At this level, 92,000 acres of salt marsh can be expected to be lost. This constitutes 42-54% of NC's current salt marsh extent. While salt marshes could migrate inland, they will not be able to migrate into developed areas. Thus, there is a need to conserve areas for salt marshes to migrate into to preserve their carbon sequestration benefits, as well as to prevent increased community exposure to inundation and flooding risks in low-lying developments (NC Salt Marsh Action Plan, 2024.)

An analysis of submerged aquatic vegetation (SAV) surveys conducted by APNEP and NC DMF indicated net loss of 56,520 acres, or 39% of the historical extent, between 1981 and 2019. Low-salinity SAV has not been sufficiently mapped to provide a statewide estimate of change in areal extent, but APNEP's 2014-2017 surveys of the linear extent of shoreline-fringing low-salinity SAV indicated a net loss of over 51 km, or 33% of the historical extent.

Seagrasses (submerged aquatic vegetation, or SAV) and salt marshes are essential types of NWLs storing GHGs. Their loss would eliminate a significant portion of the benefits that NWLs provide statewide.

Implementation Needs and Capacity

Beneficial types of projects to restore coastal habitats include:

- Conservation easements and acquisition of land that marshes could migrate into, focused on areas where there is development pressure
- Salt marsh enhancement and prevention of inundation of salt marshes due to sea level rise
- Restoration of lost seagrass beds

High-salinity seagrass has experienced large declines in acreage, particularly from Oregon Inlet to Beaufort Inlet. Future seagrass enhancement projects should focus on the high-salinity regions of North Carolina's estuaries, namely coastal sounds from the South Carolina line through Core Sound plus far eastern Pamlico Sound. Marsh migration corridor conservation should be supported in the low-lying uplands adjacent to those high-salinity estuaries (NC Salt Marsh Action Plan, 2024.)

State and nonprofit partners have decades of experience putting coastal properties into conservation and implementing coastal habitat restoration projects. Relevant partners include (but are not limited to) the North Carolina Wildlife Resources Commission (WRC), NC Coastal Reserve, Duke Restore, The Nature Conservancy (TNC), the NC Coastal Federation, the Conservation Trust for NC, and regional land trusts. DEQ divisions (including DCM, DMF, DNCR and APNEP) also maintain coordination among the many relevant federal, state, academic, and nonprofit partners.

1.1.2. Measure 13-2. Peatland Conservation and Rewetting

Background and Status in NC

North Carolina's Albemarle-Pamlico Peninsula has more peatland pocosins than anywhere else in the US (NWL Action Plan 2020). Pocosins are "naturally occurring, freshwater, shrub-dominated wetlands of the Southeastern Coastal Plain with deep, acidic, sandy, peat soils" that take thousands of years to build up (Pocosins | NHP). Drained pocosins (or pocosins during drought conditions) slowly release CO_2 from their soils, but little methane (NWL Action Plan 2020.) Draining makes pocosins vulnerable to severe peat fires that rapidly release tons of CO_2, converting them from carbon sinks to sources.

Prior to ditching and draining of North Carolina's pocosins, these wetlands covered a much wider extent of North Carolina's Coastal Plain. They covered 2.25 million acres in the 1960s, but due to drainage only 700,000 acres remain (NWL Action Plan 2020.) North Carolina's peatlands are ecologically significant as part of the State's tremendous natural community

diversity and for the habitat they provide, as well as for their ecosystem services. Peatlands are home to plants and wildlife including Venus flytraps and other carnivorous plants, critically endangered red wolves, red cockaded woodpeckers, and the American black bear.

Implementation Needs and Capacity

Peatland restoration has been conducted in a number of areas in North Carolina, including on Pocosin Lakes and Great Dismal Swamp National Wildlife Refuges, through a partnerships between US Fish and Wildlife Service and The Nature Conservancy, and on the Angola Bay Game Land, through a partnership between the NC Wildlife Resources Commission and The Nature Conservancy. Peatland pocosin restoration generally involves using water control structures to return water to pocosin soils ("peatland rewetting") rather than draining the water away. This makes peat soil less susceptible to burning and restores the conditions for the soil formation, improving pocosins' net GHG emissions. The figure below presents the conservation opportunities for peatland pocosin acquisition and rewetting (NWL Action Plan, 2020):

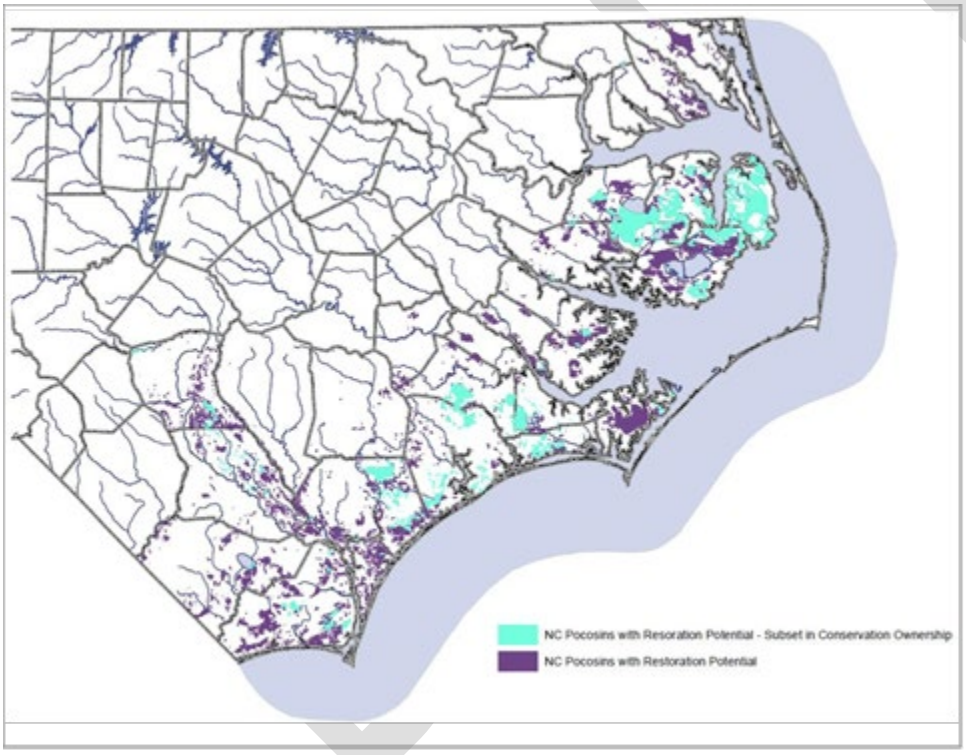


Figure B-1. North Carolina Map of Potential Pocosin Restoration

Peatland Rewetting Opportunities

Future peatland pocosin restoration will need to occur on both public and private lands, as many opportunities on public lands have been implemented already. Restoration projects require ongoing maintenance and management to ensure hydrologic measures and ecological uplift are retained (NWL Action Plan, 2020). Measurements of carbon emissions

in restored pocosins show that this process can reduce carbon emissions by more than 90% or even convert the restored pocosins to net carbon sinks, depending on the final water table depth after restoration (Richardson et al., 2022).

Relevant stakeholders and partners include (but are not limited to) The Nature Conservancy, NC Coastal Federation, DNCR, DEQ, NCFS, NC WRC, APNEP, the Eastern NC Sentinel Landscape program, private landowners, engineering consultants and contractors, universities, Department of Defense, USFS, USGS, and USFWS.

Additional Benefits

Restoring pocosins to their natural condition has the potential to reduce the risk of flooding, improve water quality, provide habitat for biodiversity, improve ecosystem health, retain soil, and protect against wildfires. Stopping soil loss in low-elevation peatlands is particularly important to reduce the impacts of relative sea level rise (SLR).

The protection provided by restoring pocosins would result in reduced loss of property due to flooding and fire, improved public health due to improved air quality (in the absence of sustained peatland fires), and potential buffering of relative SLR impacts.

1.2. Measure 14. Forest Protection and Development

1.2.1. Measures 14-1 through 14-4.

Background and Status in NC

Forests cover more than 60% of NC and offset 25% of the state's gross GHG emissions (NC GHG Emissions Inventory, 2019). Most (~85%) of NC's forests are privately owned (NWL Action Plan 2020). Forests are under intense development pressure, particularly near urban areas; if not protected, these forests will likely be lost.

Restoring forest lands offers one of the largest NWL sector pathways to carbon sequestration, by storing carbon aboveground in standing tree biomass as well as increasing soil carbon. Forested floodplains and wetlands also provide significant climate resilience, biodiversity, and water quality benefits (NWL Action Plan 2020).

Forest restoration and reforestation have been successfully conducted across the state through numerous cost-share programs which provide financial assistance to landowners to lessen high upfront costs to forest landowners of implementing forestry practices. The NC Forest Service's Forest Development Program is one such long-standing example. Forest restoration generally involves site preparation, tree planting, prescribed burning, and forest stand improvement treatments (N.C. Forest Service - Forest Development Program | NC Agriculture, 2024).

Implementation Needs and Capacity

North Carolina has 11.7 million acres of forests and 2.2 million acres of forested wetlands with high carbon storage potential that are currently unprotected. Additionally, about 5.1 million acres of land is not currently forested or developed that could potentially support reforestation (NWL Action Plan, 2020).

Organizations with experience protecting and restoring forestlands in North Carolina include (but are not limited to) state agencies NCFS, DEQ, DNCR, NC WRC, NC State Extension, and NC Soil and Water Conservation; nonprofits like the Roanoke Cooperative, The Nature Conservancy, the NC Coastal Federation, Coastal Land Trust, Conservation Trust for North Carolina, The Conservation Fund, Pew Charitable Trusts, and the Forest Legacy Program; universities like NC State University and NC A&T University; and federal programs like NRCS, USFS, USFWS, and NPS.

Additional Benefits

Restoring forest lands can increase biodiversity by providing food and habitat for native species. 441,000 acres of land in North Carolina that could be reforested and that was highly rated (> 5) on the NHP Biodiversity and Wildlife Habitat Assessment (Biodiversity and Wildlife Habitat Assessment | NC OneMap, 2023).

Urban forests can reduce the urban "heat island" effect, reduce household energy demands for both heating and cooling, absorb rainfall and as such, reduce flooding and water quality issues, and recharge drinking water supplies. Natural areas can also positively influence real estate values and local tax revenue (NWL Action Plan, 2020).

Appendix C. Meaningful Engagement and Stakeholder Input

NCDEQ designed and implemented a multi-pronged community engagement strategy to support the development of North Carolina's Comprehensive Climate Action Plan (CCAP). The approach emphasized regional reach, transparency, and inclusion, with the goal of creating space for all North Carolinians to meaningfully participate in the planning process. Outreach focused on local and regional governments, tribes, public agencies, nonprofit organizations, and residents, particularly in rural and low income areas that experience high energy costs.

1.1. List of Engaged Organizations

No.	Organization
1	City of Wilmington
2	Wilmington New Hanover County
3	Town of Carrboro
4	Orange County
5	Town of Chapel Hill
6	City of Hendersonville
7	City of Asheville
8	The Research Triangle Cleantech Cluster
9	Mecklenburg County
10	Town of Boone
11	Buncombe County
12	City of Raleigh
13	City of Greensboro
14	Fountain Works
15	Robinson Consulting Group
16	Town of Davidson
17	Town of Morrisville
18	New Hanover County
19	Forsyth County
20	City of Winston-Salem
21	Town of Hillsborough
22	Columbus County
23	Cumberland County
24	Robeson County
25	Wake County
26	McDowell County
27	Warren County
28	Halifax County
29	Central Pines Regional Council

30	Durham County Government
31	Cities Initiative
32	Center for Energy Education
33	KPMG, College of the Atlantic
34	North Carolina Department of Natural and Cultural Resources
35	Conservation Trust for North Carolina
36	Sustainable Sandhills
37	NCDOT
38	North Carolina State University

1.2. Spotlight Interview Questions and Summaries

1. Are you with an organization that is helping reduce GHG emissions, or are you an individual concerned with climate change?
2. Can you give a brief description of what project/projects that you or your organization are currently doing within your community?
3. What are some of the top concerns that you have or within your community?
4. What barriers are preventing you from engaging in actions that help reduce greenhouse gas emissions?
5. How have you/your family been impacted by climate change?
6. What are your top priorities to help reduce climate degradation?
7. What actions have you or your community taken or plan to take to reduce GHG emissions? (You could provide a targeted list here to reduce the discussion.)
8. What specific actions do you wish were in place in your community?
9. Do you have concerns about unintended consequences (like increased traffic around EV charging stations) of climate action?
   If yes, please describe.
10. Has your entity developed a plan to reduce carbon and other greenhouse gas (GHG) emissions?

1.2.1. Interview with Barbara Melvin – 6/4/2025

Barbara Melvin, representing the North Carolina Indian Housing Authority, shared her organization's work in providing energy-efficient, affordable housing to low- and very-low-income families in rural southeastern North Carolina. Through partnerships with USDA Rural Development[1] and SystemVision[2], they have been building houses that help reduce greenhouse gas emissions and lower utility costs for the owners. Melvin stressed the importance of incorporating sustainable practices in building codes and educating both homeowners and contractors about energy efficiency. She also highlighted the challenge of limited support for modifying existing homes and the critical need for outreach and hands-on assistance in low-income communities, especially with seniors. Melvin left us with this thought: "*We all have to be willing to share our knowledge and help one another because the small things we do make a big difference, and we could change the world with them.*"

1.2.2. Interview with Warren Darrell – 5/7/2025

Warren Darrell, actively teaches climate science at UNCW[3] and Duke[4] while volunteering on wetland restoration projects. His key concerns include public apathy and misinformation about climate change. Darrell noted barriers such as lack of efficient transportation alternatives and limited market options for low-emission vehicles. Darrell also advocates for improved energy management in public buildings, especially schools, and recognizes public education's fundamental role to enabling political and systemic change. Darrel left us with this: "*If our school systems and government jump manage their energy use by using automation, more efficient lighting, and more efficient air conditioning, there's a synergy with education. Energy savings for an entire school division can also be integrated into the lesson plans, for both academic levels, the students who are going to move on to engineering and science, and on the technical level for the students interested in hands-on careers.*"

1.2.3. Interview with Jonelle Kimbrough (Sustainable Sandhills) – 5/1/2025

Jonelle from Sustainable Sandhills[5] discussed the nonprofit's comprehensive efforts to promote sustainability across 11 counties in North Carolina. Their programs focus on encouraging alternative transportation, electric vehicle education, carbon sequestration through tree planting in schools, and community awareness around energy and water conservation. Kimbrough highlighted a few challenges that included limited funding, staff capacity, and resistance in rural, conservative, and transient communities. A highlight of their work is a school-based carbon bank that has sequestered nearly 1,000 tons of carbon through over 4,000 trees. Jonelle's key message: "W*e want participation from as many people as possible in sustainability. We don't want that one person doing it perfectly, we want a million people doing it imperfectly.*"

1.2.4. Interview with Carla Norwood and Jenni Rogan – 5/1/2025

Jenni Rogan and Carla Norwood of Working Landscapes6 discussed their nonprofit's work supporting rural community development, particularly in Warren County, NC. Their initiatives include operating a food hub to connect local farmers with institutional buyers, promoting soil health practices, and engaging in resilience planning with small towns. Some of the challenges that they emphasized rural areas face include limited climate infrastructure, aging housing stock, inadequate funding, and public disconnection from nature. They highlight the importance of place-based solutions—like skill-building for low-energy living and increasing electrification—and stress that effective climate strategies in rural communities differ significantly from urban models. A lack of EV charging stations, reliance on inefficient housing, and agriculture's climate impact are among their key concerns. Jenni Rogan mentioned *"Climate change impacts all parts of life… I try to make decisions based on my kinds of habits and lifestyle."*

2. Online Survey Results

2.1. CPRG Personal Survey Results

The Climate Pollution Reduction Grant (CPRG) survey is a public feedback tool aimed at shaping input to North Carolina's next statewide climate strategy. The survey collected responses from

residents and stakeholders and invited them to share their input on greenhouse gas reduction priorities and individual actions respondents are taking to reduce their personal greenhouse gas reductions. The survey will help ensure that the CCAP aligns with community concerns.

The CPRG Survey reached 110 individuals over a period of 147 days. The survey was promoted through social media, emails, and message boards. The age demographic ranges from under 18-65+, with 1% under 18, 25% of the responders being between the ages of 18 and 30, 23% from 31-50, 18% 51-65, and 30% over 65. The geographic areas of the surveyed were 31% suburban, 29% small town, 18% rural, and 21% from an urban city. The household incomes range is from $0-$130,000+ with 17 preferring not to say. 37% surveyed identified as White or Caucasian, 2% Asian or Asian American, 2% Black or African American, 3% Hispanic or Latinx, and 2% identify as two or more races/ethnicities. 23% identified as women, 7% men, and 1% non-binary. 2% identified as differently abled and 3% immunocompromised. 4% are students and 2% are veterans. 5% identified with LGBTQIA+ and 2% preferred not to answer the question. The majority of the surveyed group find emails and social media to be the most effective point of contact for information about the Comprehensive Climate Action Plan.

The results concluded that 94% of NC residents surveyed are interested in learning about climate change and reducing GHG emissions. 43% of those surveyed were not affiliated with a government or non-profit agency. (Figure 1) The majority's level of knowledge surrounding greenhouse gas emissions and the impacts of climate change was "somewhat knowledgeable" with 0% having no knowledge at all. (Figure 2) When asked on a scale from 0 to 10, with 0 being "not important at all" and 10 being "extremely important," how important is reducing greenhouse gas emissions to you? The surveyed scored a 68 on the Net Promoter Score, this meaning more found greenhouse gas emission reductions important. (Figure 3) When considering their concern about severe weather events, reduced air quality, prolonged drought, damage to wildlife and habitat, recurrent flooding, impacts on agriculture and food production, and extreme heat, the majority of the surveyed all expressed they were very concerned with all listed with some requesting more information. (Figure 4) Out of the surveyed, only three expressed they have not been personally or adjacently impacted by climate change. (Figure 5) The majority of the surveyed labeled industry, electricity, and transportation in their top three most important sector for reducing GHG emissions and the majority labelled agriculture, waste, and commercial and residential buildings in their bottom three. 21 % deemed electricity the most important sector for reducing greenhouse gas emissions and 24% chose transportation and 32% chose industry as number one. (Figure 6) 91 of the surveyed chose transition to renewable energy as a top priority to help reduce climate degradation, and over 70 said to reduce landfill waste, and develop more sustainable food systems were top priorities as well. (Figure 7) Improving air, water, and soil quality as well as conservation and habitat protection were chosen as the most important co-benefits of reducing greenhouse gas emission. (Figure 8) Only two participants claimed to not be taking any steps to reduce greenhouse gas emissions. 87 participants claimed to use energy efficient light bulbs and 77 use energy efficient appliances, 67 consolidate their daily car trips, 81 reduce and recycle waste, 65 eat less meat and dairy, and 59 compost organic waste. 44 participants claim to use electric powered rather than gas powered lawn equipment. 56

support local and sustainable food sources and 53 have planted native and adapted plants in their yard. (Figure 9) The biggest barrier that prevents the surveyed from engaging in emission reducing activities is the cost and affordability and limited access to public transit. (Figure 10) 78 out of the 110 stated that they wish more actions were in place for more renewable energy sources used in their community and 63 wish for more available public transportation. (Figure 11) With more government support the majority said they would install solar power and make their homes more energy and water efficient. (Figure 12) When considering disbenefits or unintended consequences of electric vehicles, 50% of the surveyed stated to have no concerns, 24% having concerns, and 26% were unsure. (Figure 13)

The two responses that answered yes to being a part of an entity that has developed a plan to reduce carbon and other greenhouse gas (GHG) emissions both expressed that the main barriers they face are funding, staffing, and knowledge. They also stated that they do not have the workforce to implement the plan but do have a baseline GHG emission inventory derived from either state government or self-developed. Only half identified all the possible GHG sources and either represent the GHG reduction goals by year or percentage. The plans specified do not have an outline to track reductions. The one hotspot emphasized by one plan was fleet building and energy. Only one plan included community engagement and a data quality assurance plan. The community engagement was conducted through virtual and in-person meeting, as well as a website. Both plans include future data collection.

Supporting figures from the survey:

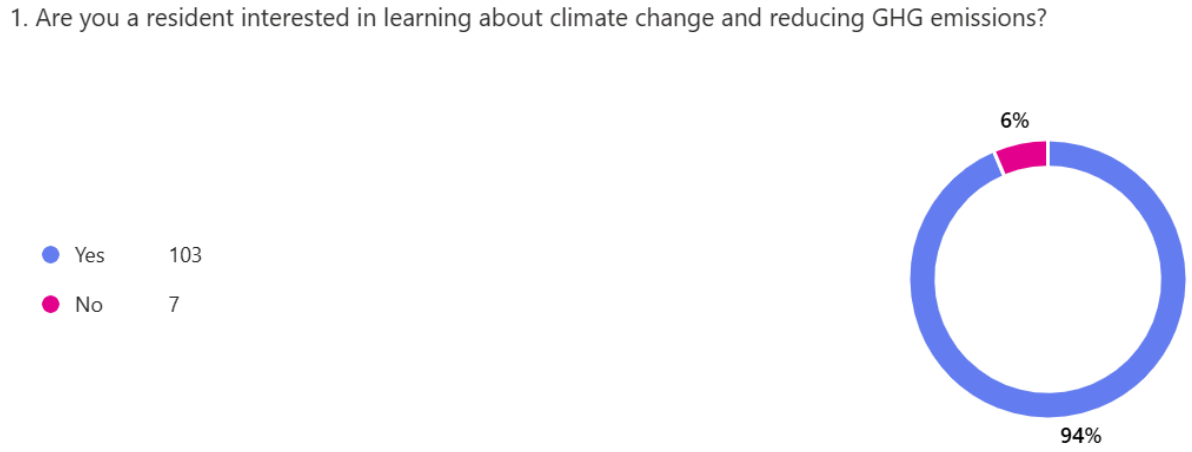


Figure C-1: General Interest

5. What level of knowledge do you have about greenhouse gas (GHG) emissions? (where they come from, how they imp act our daily lives and our climate, etc.)

No knowledge	0
A little knowledge	20
Somewhat knowledgeable	58
Expert knowledge	24

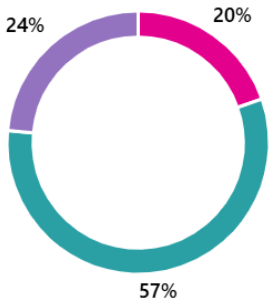


Figure C-2: Knowledge surrounding greenhouse gas emissions

6. How important is reducing greenhouse gas emissions to you? Select a value from 0 to 10, with 0 being 'not important at all' and 10 being 'extremely important'

Promoters	74
Passives	23
Detractors	5

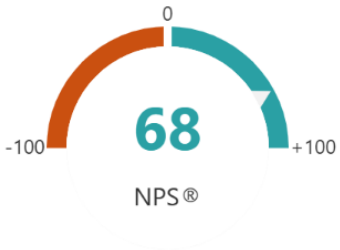


Figure C-3: Importance of greenhouse gas reduction

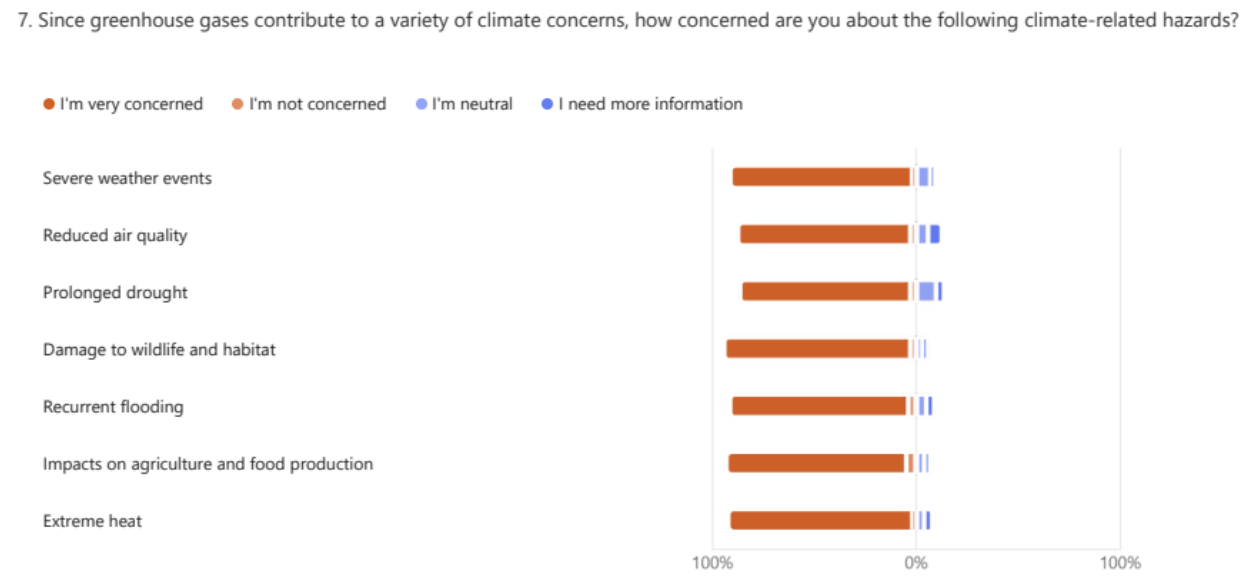


Figure C-4: Climate concerns

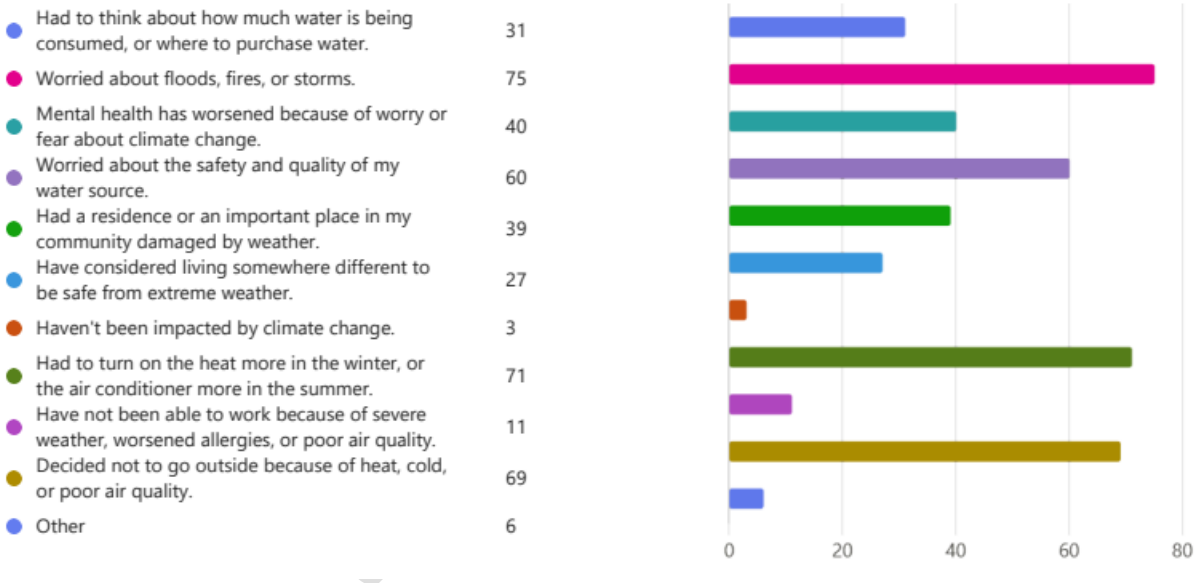


Figure C-5: Personal impacts from climate change

9. As part of this process, six sectors have been identified for reducing greenhouse gas emissions. Electricity, Commercial and Residential Bui ldings, Transportation, Waste, Agriculture, and Industry. Please rank these sectors, with the most important at the top and the least impor tant at the bottom.

Figure C-6: Most important sectors

10. What are your top priorities to help reduce climate degradation? Select all options that resonate with you.

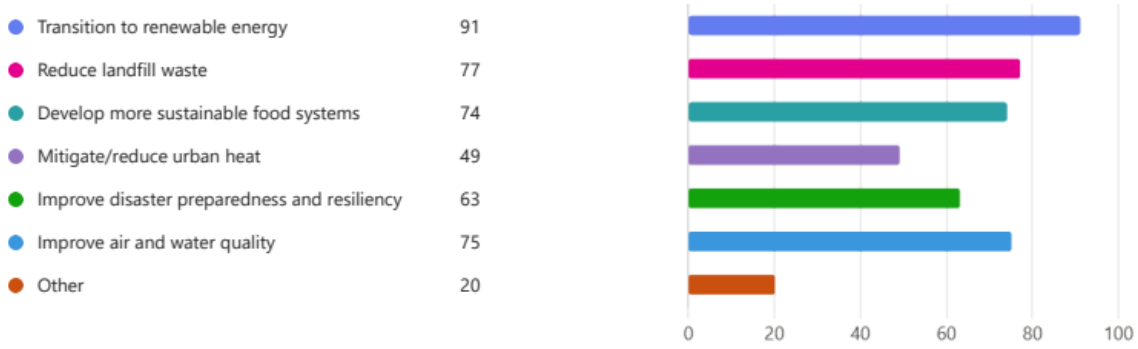


Figure C-7: Priorities to reduce climate degradation

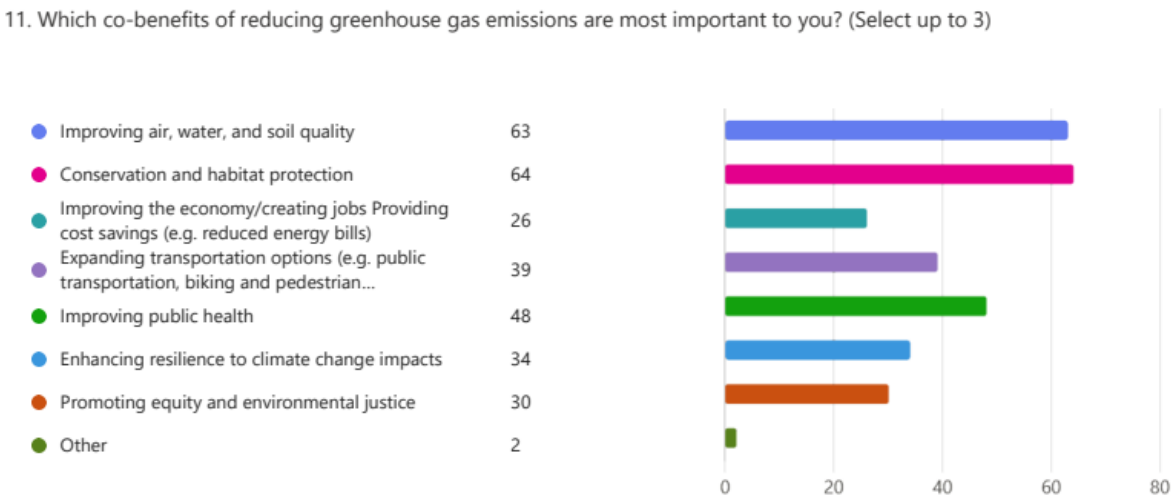


Figure C-8: Important co-benefits to reducing greenhouse gas emissions

12. Are you taking any actions to help reduce greenhouse gas emissions? If so, select all that apply.

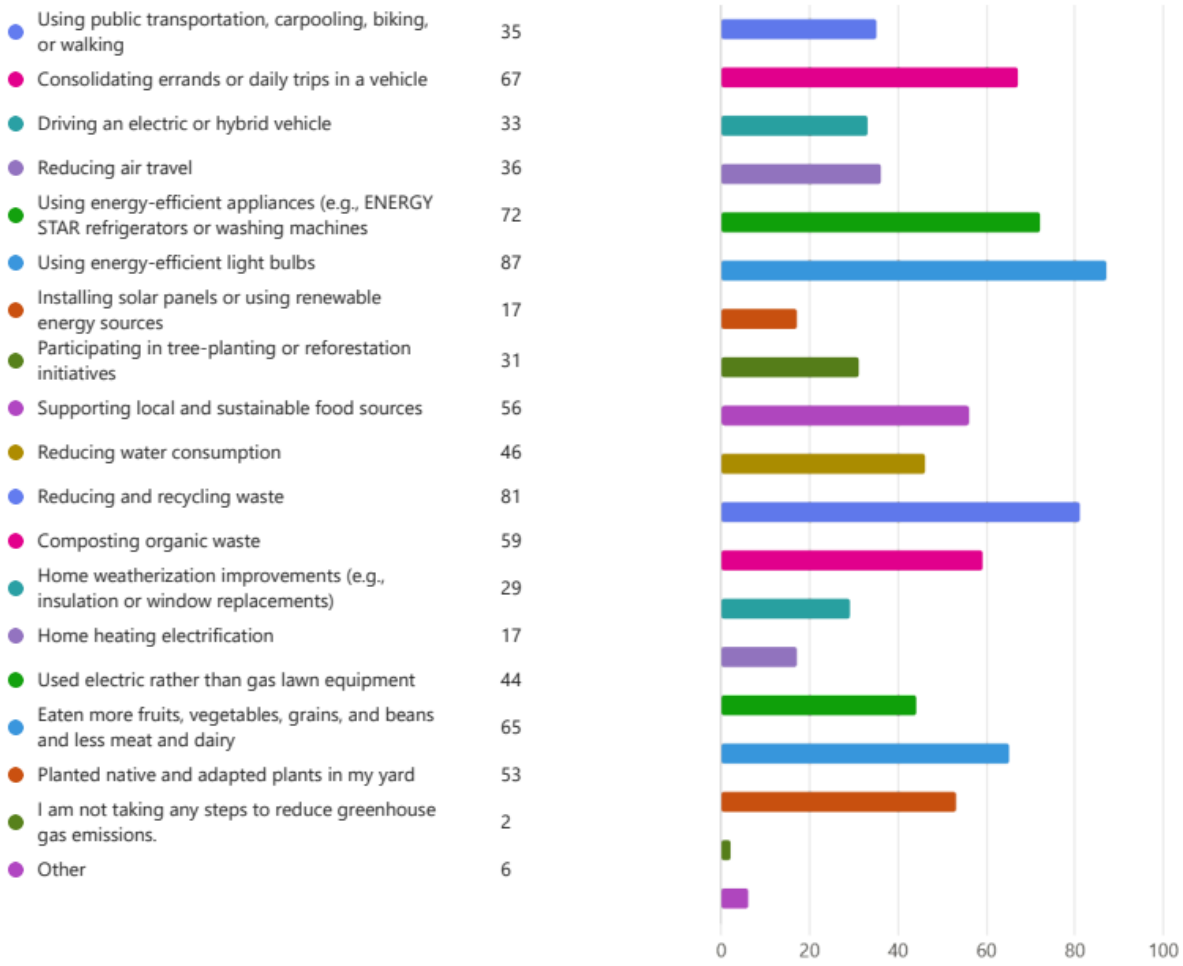


Figure C-9: Personal Actions

13. What barriers are preventing you from engaging in any of the above activities? Select all that apply.

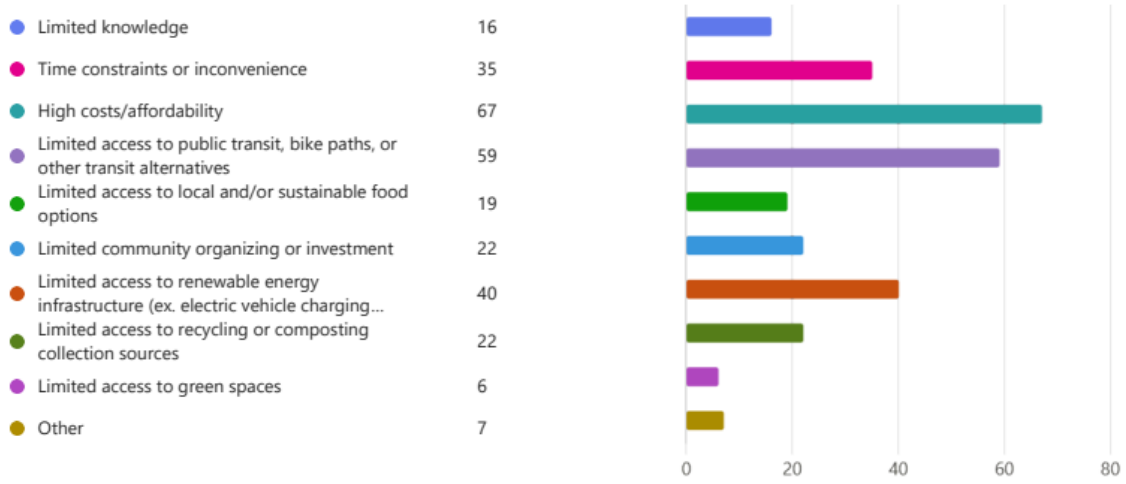


Figure C-10: Barriers to engage in personal greenhouse gas emission reductions

14. What specific actions do you wish were in place in your community? Select up to 5.

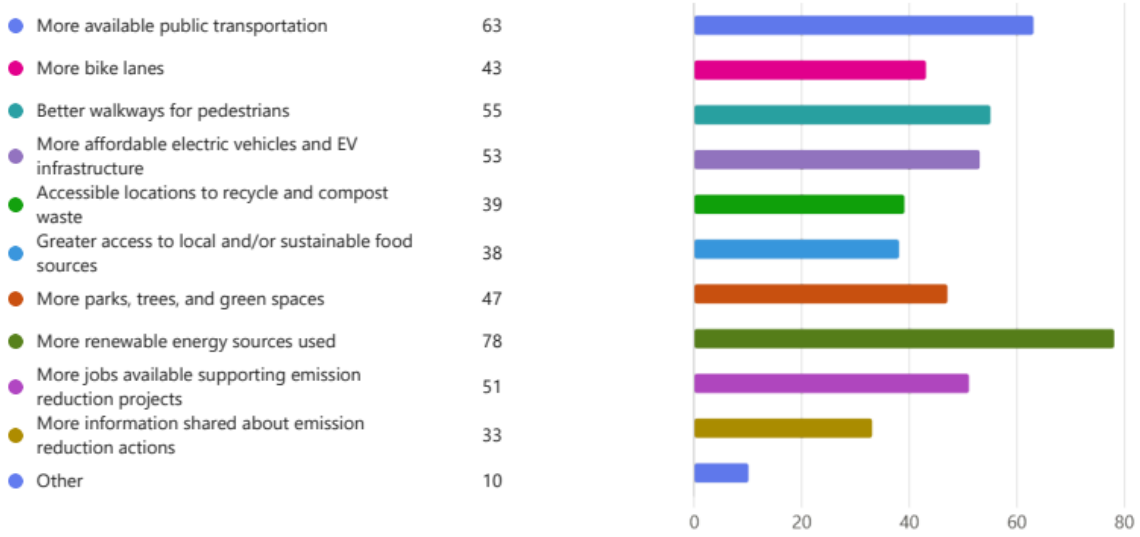


Figure C-11: Preferred future actions in their community

15. If you had support from your local government, (e.g. free services, tax incentives or safe walkways) which additional actions would you consider taking? Please select all that apply.

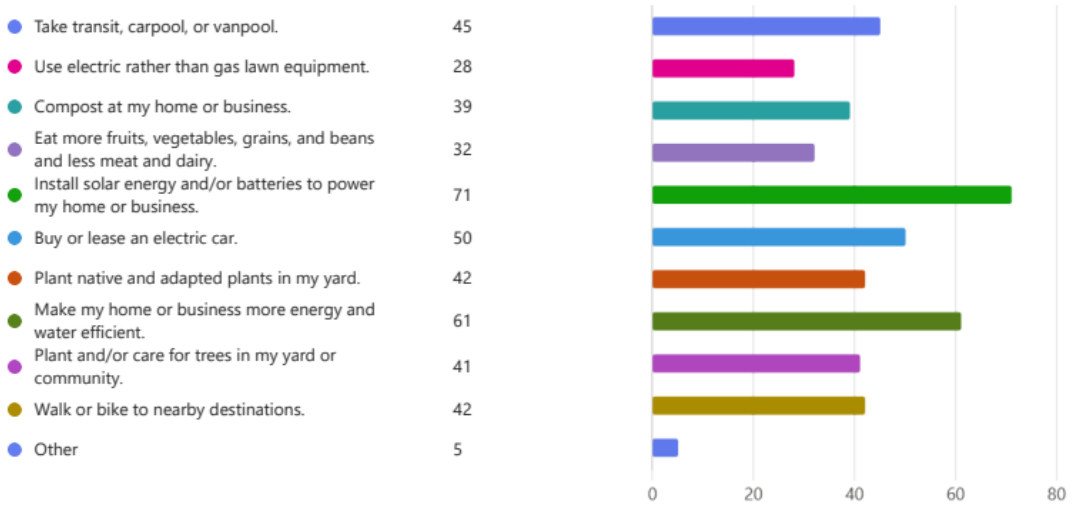


Figure C-12: Preferred local government actions

16. Do you have concerns about disbenefits or unintended consequences (like increased traffic around EV charging stations) of climate action?

Figure C-13: Concerns about disbenefits or unintended consequences of climate action

2.2. Landfill Survey Results

The NC Landfill Cover Survey was open for 37 days and received 29 responses. It was created by the NC Department of Environmental Quality to engage with North Carolina landfill operators about their current management practices and interest in reducing their greenhouse gas emissions. Methods to receive responses for this survey was though emails and phone calls with landfill operator contacts. The survey received 29 responses from these counties: Burke, Camden, Cleveland, Edgecombe, Transylvania, Cherokee, Anson, Surry, New Hanover, Granville, Orange, Alleghany, Davidson, Caldwell, Forsyth, Avery, Cabarrus, Wilson, Carteret, Greene, Granville, Pasquotank, Chatham, Moore, Mecklenburg, New Hanover, and Wilkes. Insights received from this survey include what counties and facilities are currently limiting their greenhouse gas emissions, general interest and concerns surrounding management changes for GHG emission reductions, and information needed for future actions.

The survey asked operators the following questions and gave respondents the option of adding additional comments or suggestions:

1. Does your landfill have a methane collection or control system?
2. Are you considering future methane emission upgrades?
3. What are the biggest challenges to landfill cover upgrades?
4. Are you interested in decarbonizing your waste collection fleet through electrification or engine conversion?
5. What additional support would be helpful?

The responses showed wide variation in current practices. They provide insight into current landfill practices, challenges, and interest in future methane reduction measures. Key findings include:

1. Final Cover Status
    - Fourteen facilities reported having no engineered cover.
    - Eight reported only having a partial cover.
    - Six reported installing an engineered cover.
    - One facility was unsure of their type of cover.
    - Three facilities indicated plans to install or upgrade within the next five years.

2. Methane Control Systems
    - Fifteen facilities reported no methane control systems.
    - Eight reported having an active system.
    - Five reported a passive system.
    - One facility was unsure if there was any methane control system.

3. Barriers to Cover Upgrades
    - Cost was the most frequently cited barrier to cover upgrades.
    - Lack of staff capacity, technical feasibility, and permitting uncertainty were also stated as challenges to installing cover upgrades.

4. Future Interest in Methane Reduction
    - Seven facilities expressed interest in early gas collection systems.
    - Four facilities are interested in some type of system improvements.
    - Several facilities stated interests in other measures (e.g., flowmeters, gas-to-energy).
    - Fifteen facilities reported no current plans for any methane reduction systems.

Appendix D. Workforce Planning Analysis Background

This Workforce Planning Analysis was developed by the North Carolina Department of Commerce in collaboration with the North Carolina Department of Environmental Quality using Climate Pollution Reduction Grant (CPRG) planning funds. While the report was prepared independently of the final CCAP measures, it provides valuable insights into the current state of North Carolina's climate-related workforce and highlights opportunities for future growth across key sectors. The full report is included here to support long-term planning, identify workforce gaps, and inform future implementation efforts tied to greenhouse gas reduction strategies.

This report outlines the expected changes to the state's workforce, identifies potential job shortages, and highlights the training needs required to support the Comprehensive Climate Action Plan (CCAP) developed by the North Carolina Department of Environmental Quality (NCDEQ).

1. Expected Changes to the Workforce

1.1. Job Growth Driven by Climate Adaptation Initiatives

In spring 2024, the Department of Commerce (Commerce or Department) commissioned a study by the firm EBP to project the number of jobs created by the clean energy transition. This section provides a high-level overview of the EBP study to inform the Workforce Planning Analysis for the CCAP.

The study takes into consideration recent statewide policies guiding climate adaptation and clean energy initiatives, including:

- **Executive Order 80:** Signed in October 2018, launched the North Carolina Clean Energy Plan and directed Commerce to study and report on workforce needs for clean energy and clean transportation.
- **Executive Order 218:** Signed in June 2021, set goals for developing 2.8 gigawatts (GW) of offshore wind energy by 2030, and 8.0 GW by 2040 and directed Commerce to establish the N.C. Taskforce for Offshore Wind Economic Resource Strategies (NC TOWERS) to provide expert advice for advancing North Carolina offshore wind energy projects, economic development and job creation.
- **House Bill 951:** Enacted in October 2021, requires a 70% cut in carbon emissions from power plants by 2030 and to achieve carbon neutrality by 2050.

The EBP report models two scenarios. The "Reference Case" assumes North Carolina will continue its current trajectory of population growth, adoption of EVs, and growth of wind and solar energy generation.

The "Growth Scenario" assumes that the state will meet its listed climate goals by 2050, including deep investments in wind and solar energy resource deployment, electric vehicles (EVs), and building energy efficiency. The Growth Scenario includes the following assumptions:

- **Offshore Wind**: North Carolina adds 2.8 GW of offshore wind energy capacity by 2032, then 8.4 GW more by 2040. After that, capacity grows at 2.9% annually, reaching 11.2 GW by 2050.
- **Solar Energy**: Solar energy generation reaches 43.9 GW by 2050, a 33% increase compared to the Reference Case.
- **Electric Vehicles (EVs)**: By 2030, half of all new vehicle sales in North Carolina are electric. By 2050, all new vehicles sold are electric. These targets align with the state's EV needs assessment and the Net Zero decarbonization plan.[1]
- **Building Codes and Construction**: Starting in 2023, all new buildings are fully electric and meet the latest International Energy Conservation Code for energy efficiency. Weatherization programs expand significantly to improve energy efficiency in existing buildings.
- **Heating and Hot Water**: By 2030, all new heating and water heating equipment sold must be high-efficiency models, such as electric heat pumps. By 2040, 100% of these systems are electric and are high efficiency across all new sales.

Based on these assumptions, the EBP report projects that North Carolina could gain approximately 9,700 additional annual jobs through 2050.

[1] *North Carolina Deep D*ecarboniz*ation* Pathways *Analysis. February 2023. Office of Governor Roy Cooper. https://cebuyers.org/wp-ontent/uploads/2025/03/IncreasesByState_NERA030525.pdf*

Each clean energy sector contributes uniquely to this job growth:

Wind Energy drives the largest employment gains (5,500 jobs annually) due to the complex, labor-intensive nature of offshore wind development. These projects require long construction periods, extensive infrastructure investments, and ongoing maintenance during operations. Job growth is strongest in construction, project management, and environmental engineering.

Solar Energy adds about 3,000 jobs per year. While installation is less complex than wind, rapid expansion and decentralized deployment (e.g., rooftop, commercial, utility-scale) create high demand for electricians, solar photovoltaics installers, and logistics staff.

Table D- 1. Estimated job growth and economic impact

Electric Vehicles investments generate around 1,000 jobs annually, primarily in manufacturing, utilities, and wholesale trade. EVs also create employment ripple effects in battery production, charging infrastructure, and grid upgrades. The estimate focuses only on light-duty vehicles *within North Carolina*, so actual employment could be significantly

Estimated job growth and economic impact by 2050 under the "Growth Scenario"			
Sector	CCAP Measure	Estimated Annual Jobs	Estimated Economic Impact ($ Billions)
Wind Energy	Electricity Generation	5,500	$24.2
Solar Energy	Electricity Generation	3,000	$7.4
Electric Vehicles	Transportation	1,000	$15.7
Building Efficiency	Commercial and Residential Buildings	<150	$1.8
Total		9,650	$49.1

higher as North Carolina advances electrification of buses[2] and heavy-duty fleets, or as EV adoption grows in other states and global markets.

Table D- 2. Industry-wide Initiatives

Initiatives in wind, solar, building efficiency, and EVs are projected to create jobs over a wide range of industries

Projected job growth of North Carolina Clean Energy initiatives by industry.

Wind	Jobs	Solar	Jobs	Electric Vehicles	Jobs	Building Efficiency	Jobs
Construction	2,681	Admin., Waste Management	722	Manufacturing	621	Manufacturing	87
Finance and Insurance	383	Transport. and Warehousing	249	Utilities	107	Wholesale Trade	8
Real Estate, Rental, Leasing	328	Real Estate, Rental, Leasing	249	Wholesale Trade	75	Real Estate, Rental, Leasing	5
Prof., Sci., Tech. Services	274	Prof., Sci., Tech. Services	199	Real Estate, Rental, Leasing	43	Transport. & Warehousing	4
Manufacturing	274	Construction	174	Finance and Insurance	32	Finance and Insurance	4
Other	1,477	Other	921	Other	193	Other	22
Total	**5,471**	**Total**	**2,490**	**Total**	**1,071**	**Total**	**130**

Source: EBP • Created with Datawrapper

Building Efficiency sees the smallest direct employment impact—fewer than 150 jobs annually—because many high-efficiency materials are already manufactured by companies that also produce traditional components. However, this sector still provides key environmental benefits and new jobs in weatherization, HVAC upgrades, and energy auditing.

1.2. Clean Energy Occupations

A diverse workforce will need to support these climate adaptation and clean energy measures.

Wind Energy

Wind energy drives the largest occupational gains, especially in construction and

[2] *For instance, the Environmental Protection Agency awarded $26.7 million to Carolina Thomas LLC to produce 114 new electric buses to school districts throughout North Carolina. https://governor.nc.gov/news/press-releases/2024/01/17/governor-cooper-tours-electric-school-bus-highlights-historic-federal-funding-114-electric-buses*

engineering roles. Projects require site preparation, turbine installation, electrical line work, and long-term maintenance. This supports high demand for construction laborers, electricians, environmental engineers, and project managers, many of whom earn above-average wages.

Solar Energy

Solar deployment creates widespread job opportunities in installation, logistics, and administrative coordination. Occupations include solar photovoltaic installers, electricians, equipment operators, and support staff managing permitting and scheduling. The sector also supports jobs in sales and project oversight due to its decentralized growth model.

Electric Vehicles (EVs)

EV growth supports jobs in advanced manufacturing, including battery assembly, motor production, and vehicle design. Additional roles emerge in software development, systems engineering, and charging infrastructure. North Carolina's strong pipeline of engineering graduates positions the state to meet growing demand in these high-tech occupations.

Building Efficiency

Jobs in this sector focus on HVAC technicians, insulation workers, and energy auditors. Most work is tied to retrofitting existing buildings and ensuring code compliance in new construction. While job creation is modest, these occupations are critical for delivering energy savings and emissions reductions across the built environment.

Table D- 3. Jobs Created by Top Occupation Categories

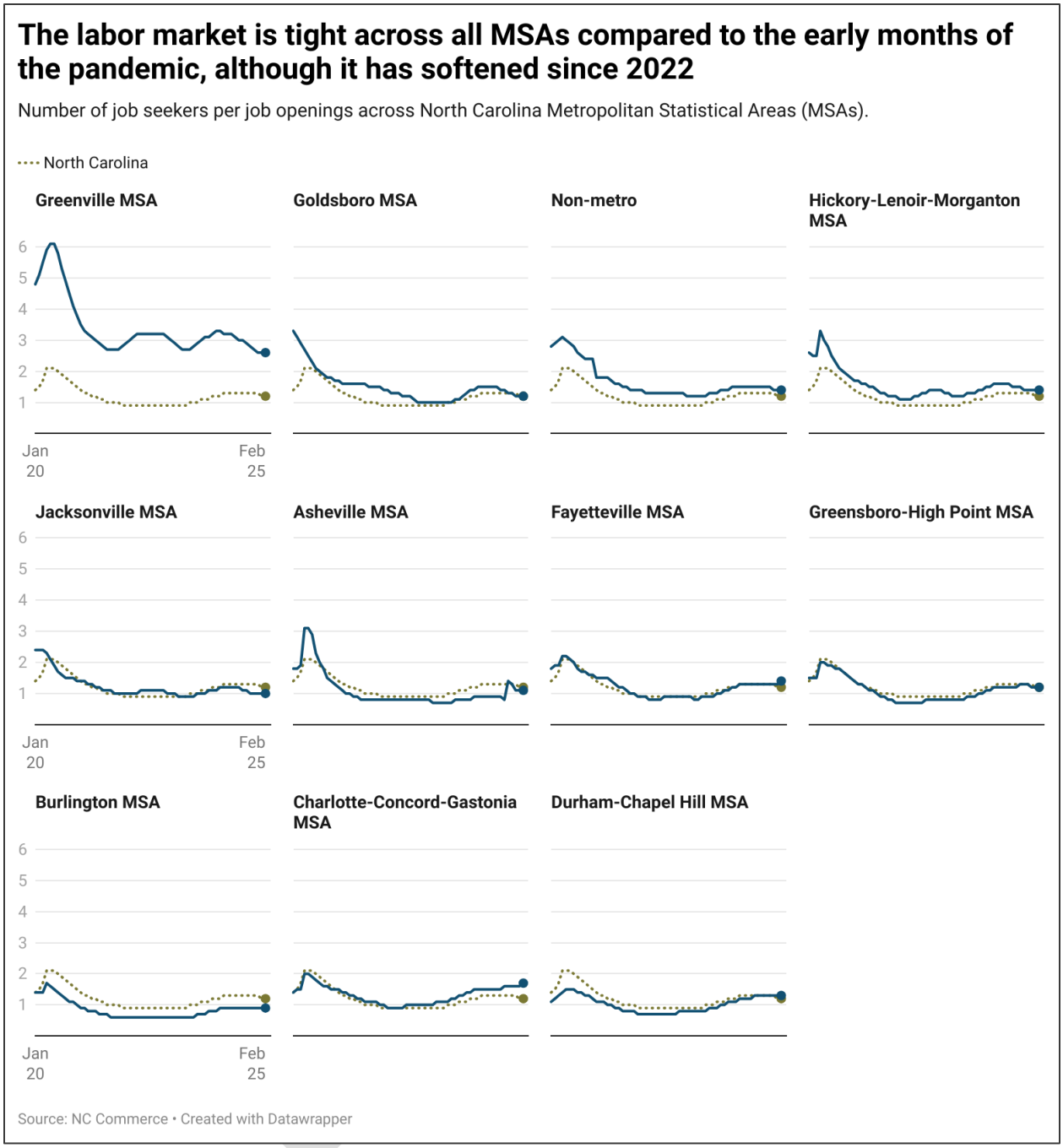
New jobs created under the Growth Scenario by top occupation categories				
Rank	Occupation	Average Wage	Estimated Jobs	Economic Impacts ($B)
1	Construction and Extraction	$50,980	1,712	$9
2	Office and Administrative Support	$48,220	1,186	$6
3	Transportation and Material Moving	$41,130	989	$5
4	Sales and Related Occupations	$79,360	880	$5
5	Management Occupations	$143,120	785	$4
6	Production Occupations	$45,260	781	$4

7	Business and Financial Operations	$85,620	767	$4
8	Installation, Maintenance, and Repair	$59,280	690	$4
9	Computer and Mathematical	$107,570	374	$2
10	Building Cleaning and Maintenance	$38,260	273	$1
	All Occupations	$59,730	9,635	$49

1.3. Labor Supply for Clean Energy Jobs

Since 2020, North Carolina's job market has tightened. As of February 2025, there are fewer jobseekers per job opening than during the early months of the COVID-19 pandemic. However, several labor market indicators have softened since 2022, including a decline in both job postings by employers and voluntary quits by workers.

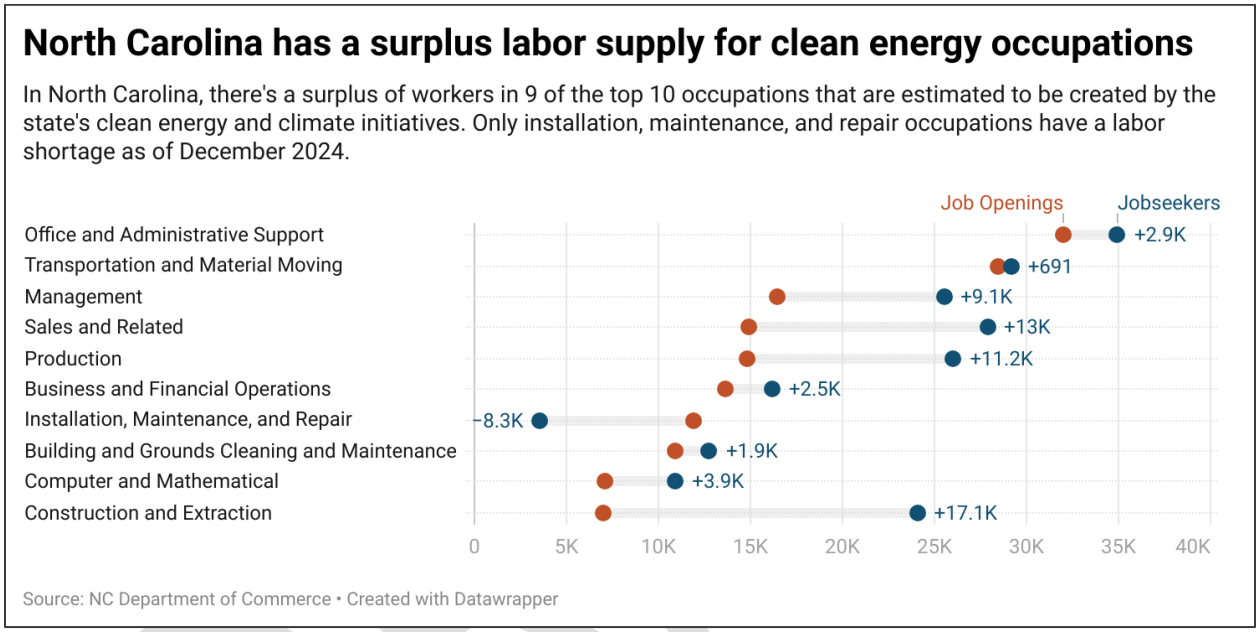
Table D- 4. Number of Job Seekers per Job Opening



Local conditions vary. For example, the Greenville metro area has about 2.5 jobseekers for every available job, which is double the state average. In Charlotte, the number of jobseekers per job is also nearly twice the state average, just slightly below what it was in March 2020.

North Carolina has a surplus of workers in high demand occupations critical to the clean energy transition. Based on data from December 2024, there were about 50,000 more jobseekers than job openings across top occupational categories identified by EBP. Worker surpluses are strongest in management, sales, production, and construction. Smaller surpluses exist in office and administrative support, transportation, business operations, and building maintenance. A major shortage remains in installation, maintenance, and

Table D- 5. Labor Surplus for Clean Energy Jobs



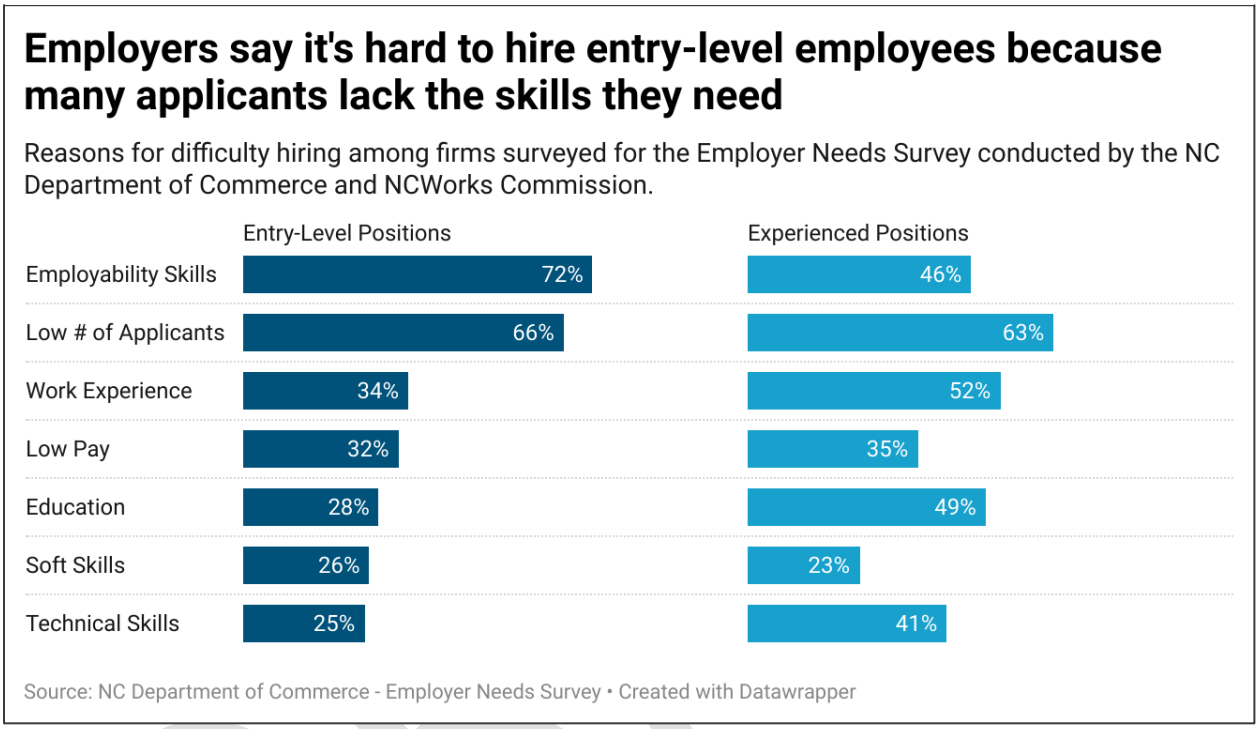
repair jobs, with 8,300 fewer workers than are currently being hired by employers. Many of these occupations work across industries such as manufacturing and construction, and are often skilled trades people.

Even with a surplus of workers in these occupations, many North Carolina employers report challenges with hiring that may be shared by future clean energy employers. A 2023 survey conducted by Commerce found that 62% of employers had trouble filling positions, up from 44% in 2014. The top stated reasons were (1) a shortage of applicants and (2) a lack of necessary skills. Over two out of three employers cited the skills gap as a major issue filling entry-level positions. This problem is particularly acute in manufacturing and construction — two industries critical to the clean energy economy.

National data on wind energy workforce shortages also point to challenges hiring for these industries. According to a 2024 report from the U.S. Department of Energy, 94% of

construction firms working in the wind industry reported at least some difficulty finding

Table D- 6. Challenges of Hiring Entry-level Employees



qualified workers, with one-third claiming it was "very difficult." Construction firms in the solar industry reported similar challenges.[3]

Many workers face additional barriers that prevent them from accepting jobs. Employers report that transportation challenges and limited access to affordable childcare are major obstacles. A 2023 study by Commerce and NC Child found that there were 100,000 fewer working-age parents of young children in the labor force compared to 2019. Childcare availability and cost were the biggest hurdles to employment. North Carolina's licensed, high-quality childcare system can only serve about two-thirds of the children whose parents work, and childcare costs have risen faster than inflation, housing, and groceries nationwide.[4]

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[3] *"United States Energy & Employment Report 2024." U.S. Department of Energy. 2024.* https://www.energy.gov/sites/default/files/2024-10/USEER%202024_COMPLETE_1002.pdf

[4] *"How Increasing Employment Among Parents of Young Children Can Grow North Carolina's Economy." NC Department of Commerce. NC Child. October 2024.* https://www.commerce.nc.gov/empowering-work-how-increasing-employment-among-parents-young-children-can-grow-north-carolinas/open

Table D- 7. Barriers to Employment

Top barriers to employment identified by employers			
Barriers	All Industries	Manufacturing	Construction
Transportation	23%	21%	18%
Childcare	20%	19%	7%
Commuting Distance	17%	17%	8%
Criminal Record	14%	14%	19%
Drug Screening	6%	10%	16%

Transportation and commuting distance also limit workers' access to jobs. In surveys, 23% of employers across all industries cited transportation as a top barrier, 20% cited childcare, and 17% cited commuting distance. In manufacturing and construction, these barriers are even more significant. In the wind energy sector, job location remains a hurdle. About 64% of students surveyed reported difficulty finding clean energy jobs near where they are willing to live.[5]

Meeting workforce needs in North Carolina's clean energy industries will require investment in skills training, education, and targeted outreach, as outlined in Section 3.

[5] *"National Wind Energy Workforce Assessment: Challenges, Opportunities, and Future Needs." National Renewable Energy Lab. Revised March 2024.* https://www.nrel.gov/docs/fy24osti/87670.pdf

1.4. Job Displacement and Transition Support

North Carolina's shift to a clean energy economy is creating new jobs while transforming or phasing out traditional roles, especially in fossil fueled-energy generation and powered industries, automobile manufacturing jobs centered around the internal combustion engine, and certain trades. The state is proactively addressing job displacement by combining workforce policy, employer partnerships, and equitable access to education and training. These collaborations are also highlighted in Section 3.

Figure D- 1. Buck Steam Station – Duke Energy's first coal-fired generation station - was decommissioned and demolished in 2018 outside of Salisbury, NC. Source: Duke Energy

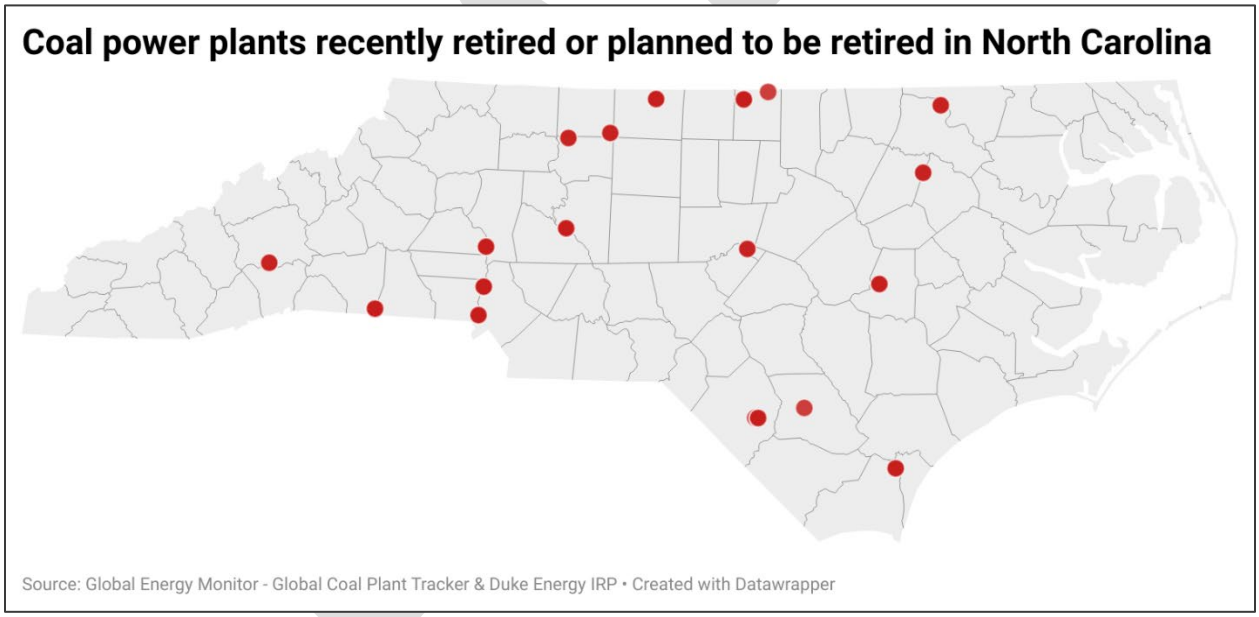


Figure D- 2. NC Coal Power Plant Retirement Schedule

2. Climate Adaptation Job Opportunities in Disadvantaged Communities and Areas Impacted by Hurricane Helene

Investments in climate adaptation initiatives and technology are likely to create job opportunities across North Carolina, and support Hurricane Helene recovery efforts in western North Carolina.

2.1. Energy Cost Burden

Implementing climate adaptation strategies has tangible benefits for North Carolina's most vulnerable populations. Statewide, over 750,000 – or 1 in 6 –households households spend more than $250 a month on electricity bills. The economic burden of electricity prices is concentrated in eastern North Carolina, where in 43 counties, more than 1 in 4 households spend $250 or more on electricity.[6]

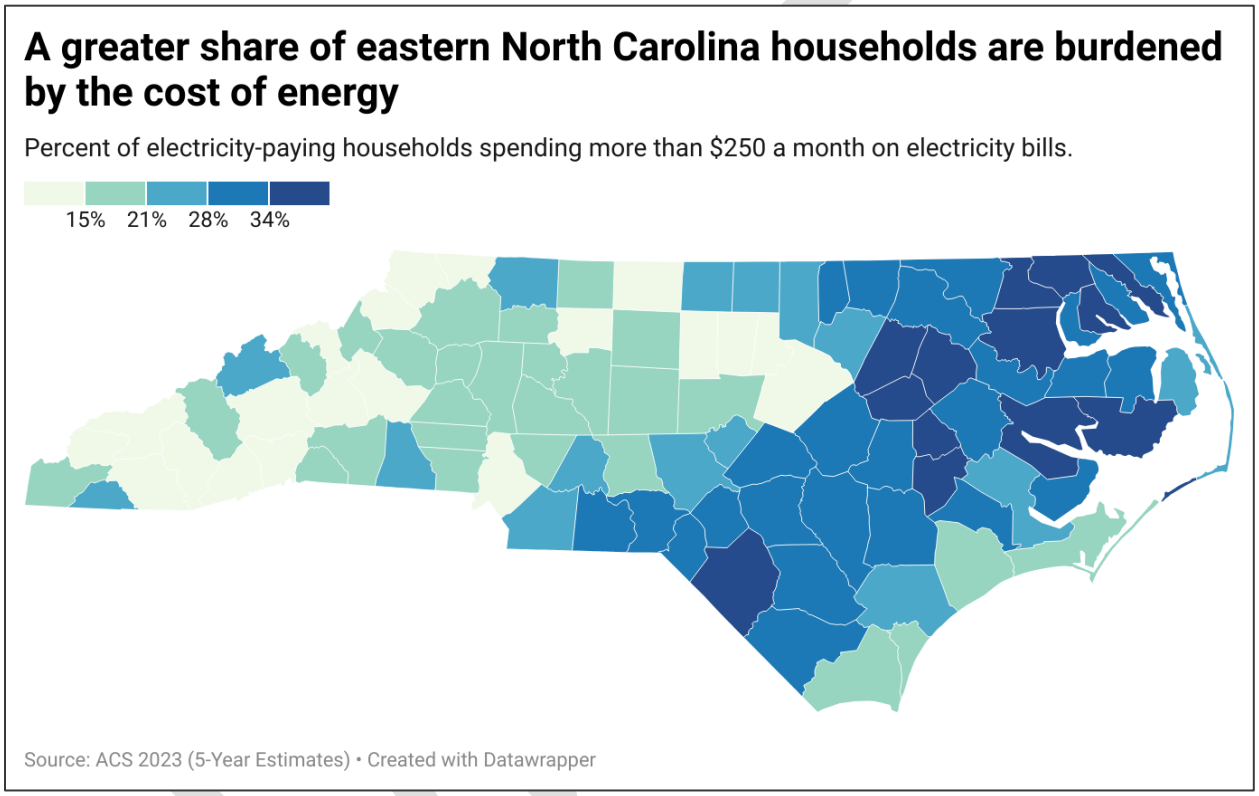


Figure D- 3. NC Household Energy Burden Costs

Two statewide initiatives – EnergizeNC and Energy Saver North Carolina – will provide more than $350 million in combined investment in residential solar and home energy efficiency. Key occupations needed to support these initiatives are electricians, solar photovoltaic installers, and HVAC mechanics – all of which are projected to grow by 2032.

Table D- 8. Current and Projected Occupation Needs and Wages

[6] *American Community Survey (2023) 1-Year Estimates. U.S. Census Bureau. https://data.census.gov/table/ACSDT1Y2023.B25132?q=electricity&g=040XX00US37&y=2023*

Occupation	2022 Employment	2032 Employment	Net Change	Hourly Median Wage
Electricians	24,700	28,000	+3,300	$24.49
Solar Photovoltaic Installers	950	1,400	+450	$18.93
HVAC Mechanics & Installers	15,600	17,600	+2,000	$24.33

2.2. Climate Adaptation Job Opportunities in North Carolina

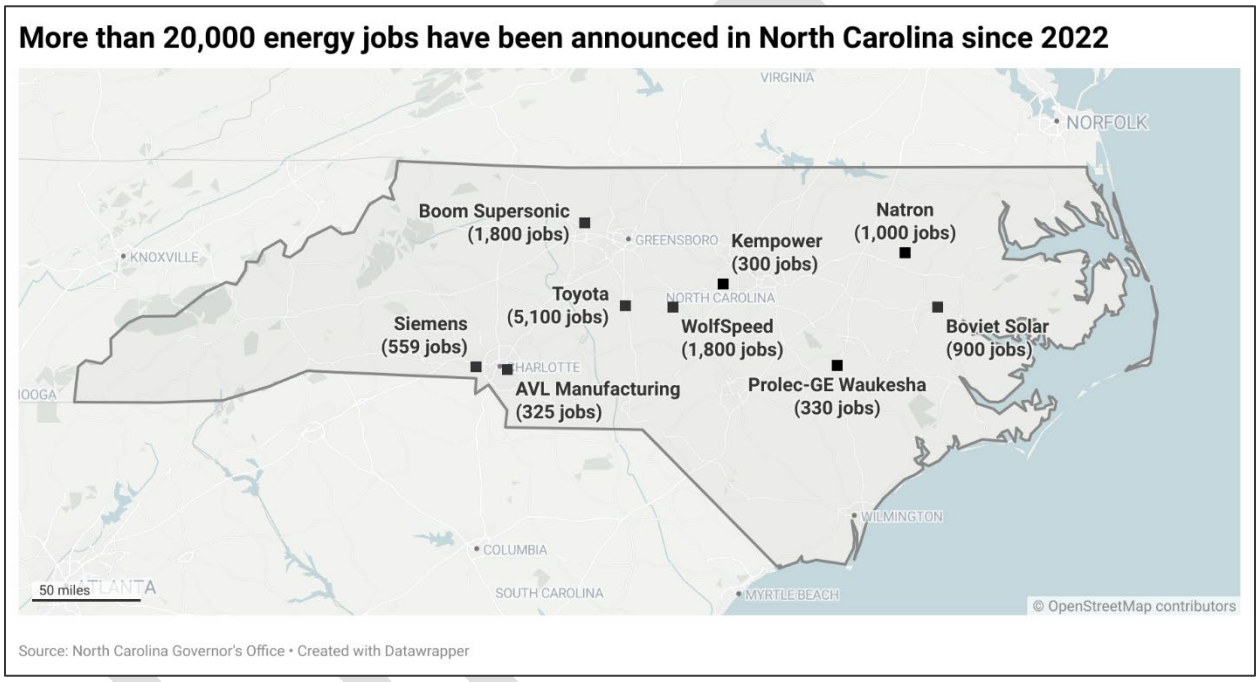


Figure D- 4. Major Clean Energy Employers in NC since 2022

Since 2022, more than 20,000 clean energy jobs have been announced by industries for large facility development or expansions in battery and solar panel manufacturing, advanced electrical grid component manufacturing, and other components critical for EV and offshore wind development.

For instance, in 2021 Toyota announced the location of the company's first global battery manufacturing plant in Randolph County. That investment of $13.9 billion will create more than 5,000 jobs. Since hiring began in 2022, Toyota is now the largest private employer in

the county.[7] Part of the company's workforce success is built on partnerships with local community colleges like Randolph Community College (RCC) and Guilford Technical Community College (GTCC). These partnerships are documented in detail in Section 3.

2.3. Workforce Training Opportunities

North Carolina's workforce training and educational assets are available in every part of the state. The NC Community College System oversees 58 colleges across 100 counties, and nearly every North Carolina resident is within a 30-minute drive of high-quality, affordable education and professional development. Similarly, NCWorks oversees more than 70 career centers around the state, sometimes co-located with community colleges. Career centers offer a suite of services to job-seekers at no charge, including career coaching, application and interview support, free internet access, and general assistance in searching for jobs. Career centers also provide specialized programs to veterans, young adults, migrant or seasonal farm workers, and justice-involved jobseekers.

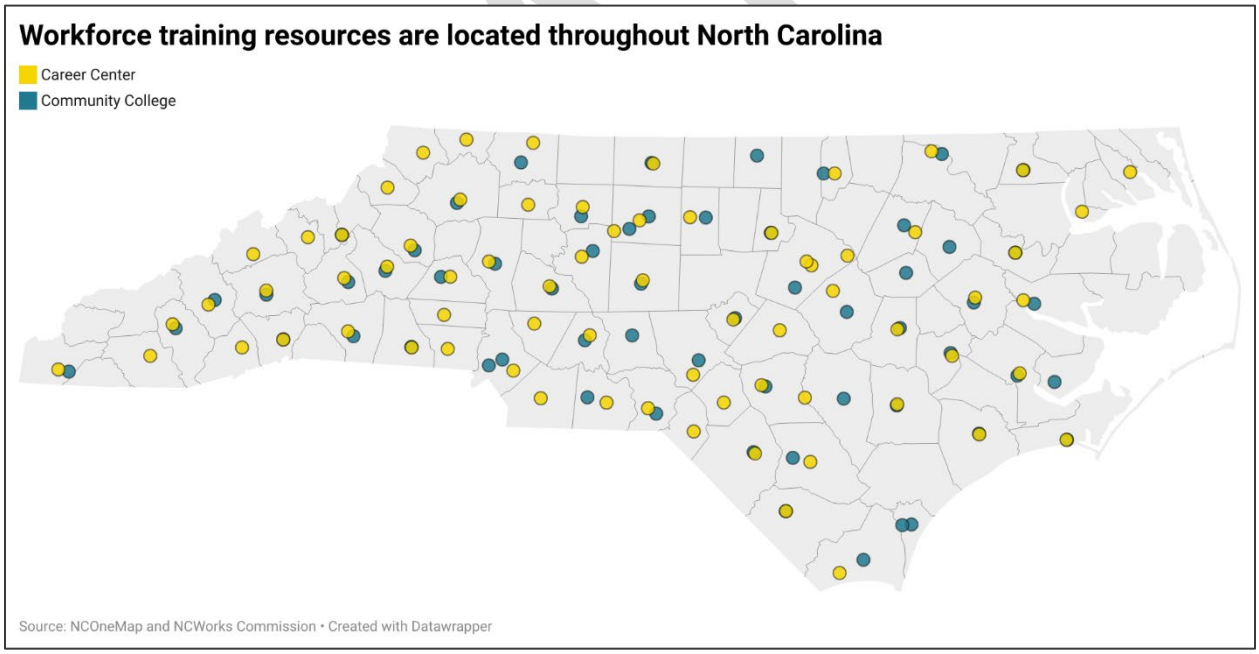


Figure D- 5. Workforce Training Resources in NC

[7] *NC Commerce Labor & Economic Analysis.* https://d4.nccommerce.com/QCEWLargestEmployers.aspx

Career centers work collaboratively with North Carolina's 20 Workforce Development Boards. Boards are made up of appointed community and business leaders and ensure that local workforce development initiatives match the needs of the community.

Section 3 describes these resources and North Carolina's workforce development system in greater detail.

2.4. Hurricane Helene Recovery

In western North Carolina, recent natural disasters have shined a light on the need for climate resiliency. According to Commerce's HUD CDBG-DR Action Plan, Hurricane Helene caused $1 billion in damage to the electrical wiring and infrastructure facilities of 25 municipal-owned systems, 7 cooperative-owned systems, and Duke Energy in a region serving nearly two million households.

The storm's extensive damage highlights the need for diverse energy resources. Hurricane Helene not only damaged electrical infrastructure but also caused $41 million in damage to gas lines, affecting 400 customers. Additionally, 10 retail propane locations were severely damaged or destroyed, resulting in the loss of 5,000 propane tanks.

Like the high cost of energy in eastern NC, intentional statewide initiatives present an opportunity to rebuild homes, businesses, and communities to be more resilient in the future. For instance, more households in western North Carolina heat their homes with

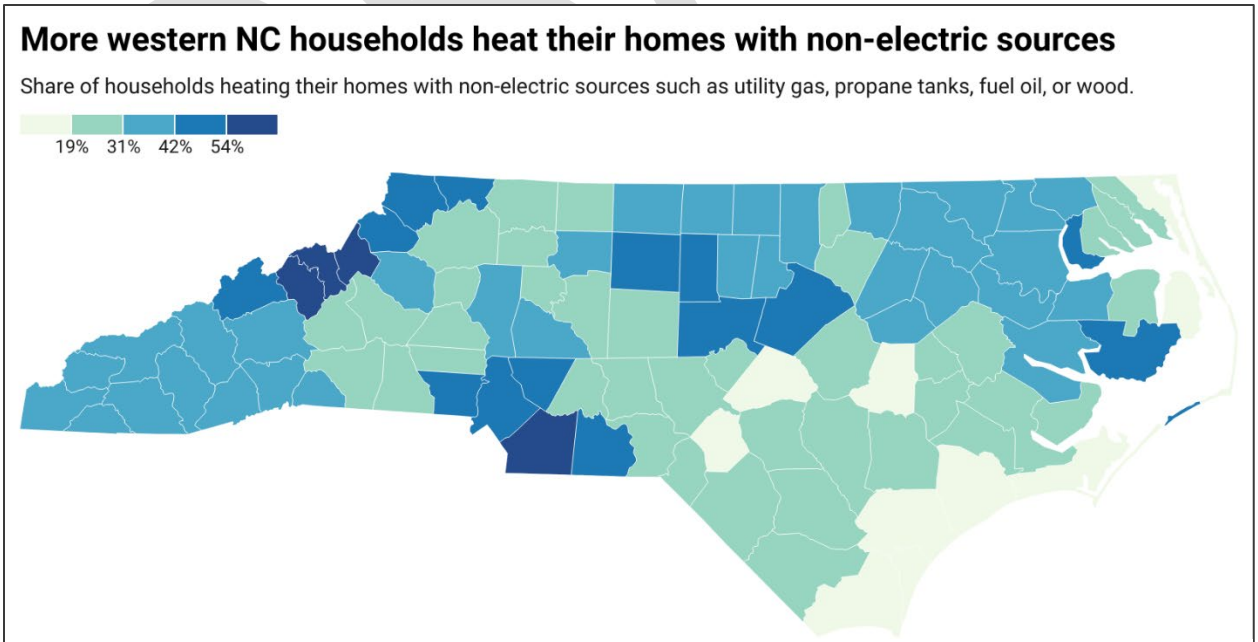


Figure D- 6. Western NC Household Heating Sources

non-electric sources. In Avery, Mitchell, and Yancey counties, approximately 2 in 3 households use non-electric sources for heat. These are opportunities to incorporate heat pumps and other cost-reducing energy technologies in the recovery and rebuilding efforts.

3. Workforce Development Collaborations and Strategies

North Carolina has a robust ecosystem of workforce development programs spanning state agencies, community colleges, universities, registered apprenticeships, community organizations, and other workforce development initiatives to meet the needs for a growing clean energy workforce.

3.1. Workforce Development Programs Serving North Carolina

The NCWorks Commission coordinates the state's workforce development system, develops policy, and advises the Governor, General Assembly, state and local agencies, and businesses on how to strengthen the state's workforce. The Commission is chaired by private sector leaders and oversees a network of local career centers, training programs, and employer services.

Several statewide initiatives drive the Commission's work. Including:

- **MyFutureNC**: A statewide initiative adopted in 2019 by the General Assembly and Governor's Office to close the educational gap. MyFutureNC's goal is to get 2 million North Carolinians aged 25-44 to hold an industry-valued credential or postsecondary degree by 2030. Since its adoption, the number of prime-age workers with degrees or credentials has grown by more than 200,000.[8]

- **First in Talent Strategic Economic Development Plan:** In 2021, in the wake of the economic changes driven by COVID-19, the state's economic development plan, created by Commerce, put talent and workforce development at the forefront of the state's economic development strategy.[9]

- **Executive Order 11**: In March 2025, Governor Josh Stein signed Executive Order 11, creating a Council on Workforce and Apprenticeship as an advisory council to the

[8] *"2025 State of Educational Attainment Report." MyFutureNC.org.* https://www.myfuturenc.org/wp-content/uploads/2025/02/2025-myFutureNC-Educational-Attainment-Report-020325.pdf

[9] *"First in Talent: Strategic Economic Development Plan for the State of North Carolina." July 2021.* https://www.commerce.nc.gov/guidelines-north-carolina-strategic-plan-economic-development/open

NCWorks Commission. The Council was directed to recommend strategic, quantifiable goals to grow and prepare North Carolina's workforce development efforts over the next four years.[10]

Table D- 9. NC Workforce Programs by Agency

Highlighted Agencies[1]	Workforce Program
Community College System	ApprenticeshipNC Program Basic Skills Customized Training Human Resources Development (HRD) Post-Secondary Career, Technical, and Vocational Education (CTE) Workforce Continuing Education (CE)
Department of Commerce	Veteran's Employment Wagner-Peyser Workforce Investment Act and Workforce Innovation and Opportunity Act – Adults Workforce Investment Act and Workforce Innovation and Opportunity Act – Dislocated Workers Workforce Investment Act and Workforce Innovation and Opportunity Act – Youth
Department of Health and Human Services	Division of Services for the Blind, Employment and Training Division of Social Services, Workfirst Employment and Training Division of Employment and Independence for People with Disabilities
Department of Public Instruction	Career and Technical Education (CTE)
Governor's Office	NC Business Committee for Education Governor's Council on Workforce and Apprenticeships

[10] *Executive Order No. 11 Directing North Carolina's Progress on Workforce Development. March 25, 2025. https://governor.nc.gov/executive-order-no-11-directing-north-carolinas-progress-workforce-development*

3.2. Workforce Development Partnerships to Meet Clean Energy Workforce Demand

3.2.1 ApprenticeshipNC

ApprenticeshipNC, North Carolina's State Apprenticeship Agency, helps businesses develop Registered Apprenticeship Programs tailored to meet their workforce needs. Registered Apprenticeship is the gold standard for work-based learning, combining hands-on training with classroom instruction, structured wage progression, and nationally recognized credentials. Since 2015, the number of individuals enrolled in a registered apprenticeship program has more than doubled.

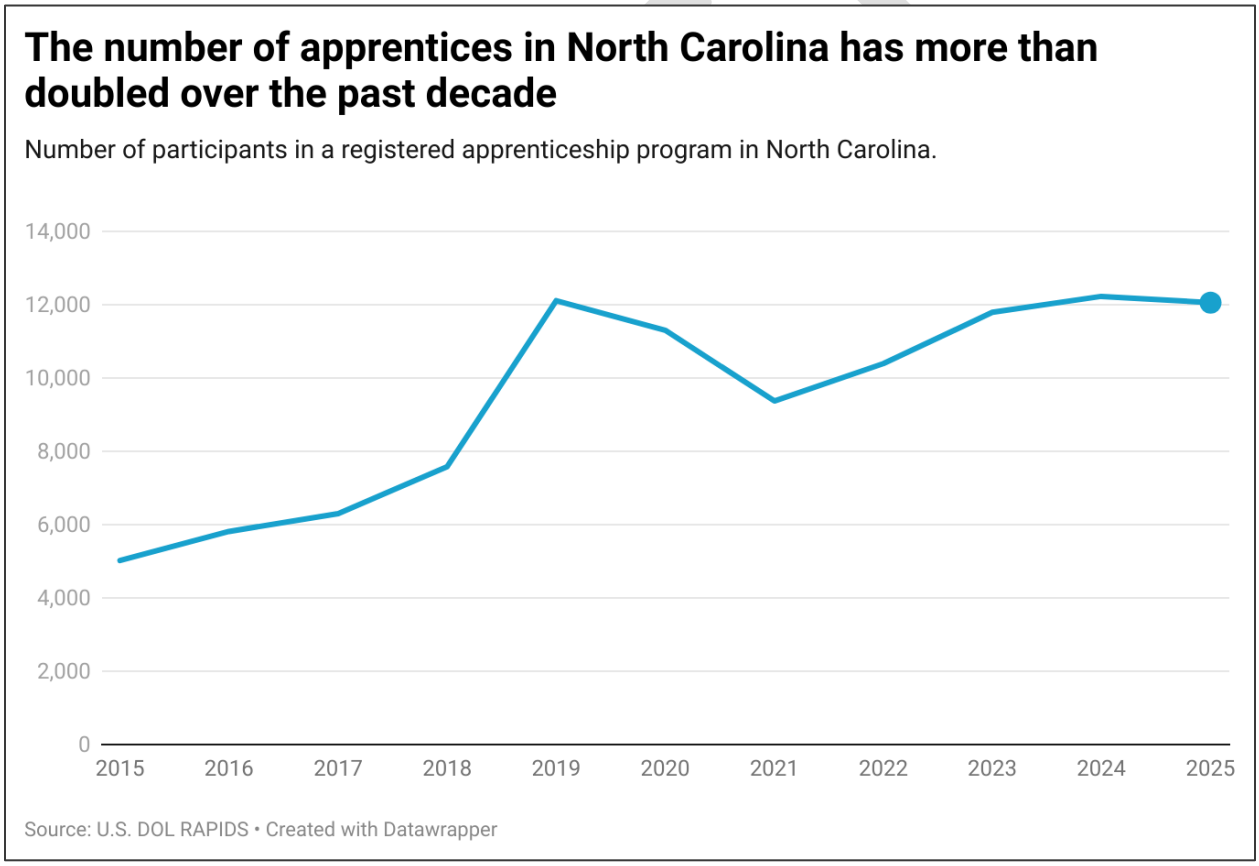


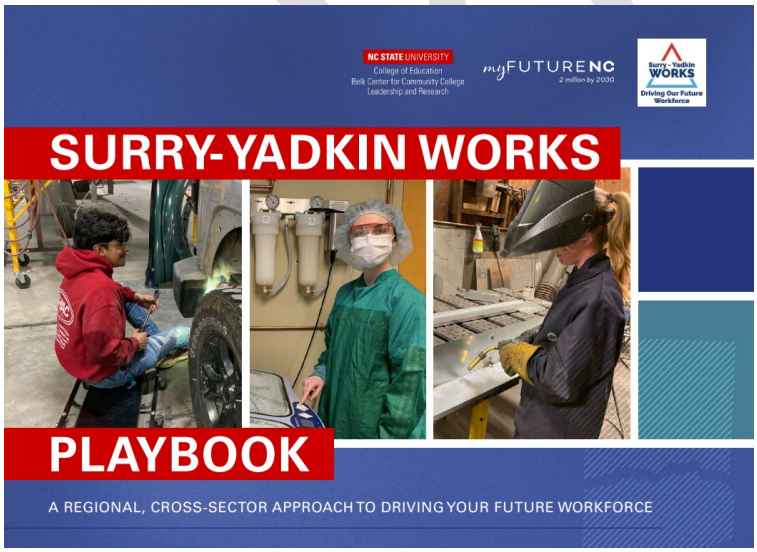
Figure D- 7. NC Apprentices 2015-2025

In its 2024 annual report, ApprenticeshipNC reported that the largest occupational segments of new enrollments were those in installation, maintenance, and repair – one of the occupations projected to have the biggest shortages from clean energy-related jobs outlined in Section 1.[11] For example, Randolph Community College's (RCC) Industrial Maintenance Technician (IMT) Apprenticeship creates a pipeline to companies like Toyota and Energizer. This program is unique – providing a wide range of skills to students including welding, electrical work, fabrication, and automation. Students spend three paid

Surry-Yadkin Works Apprenticeship

Surry County has the highest rate of apprenticeship and the third largest number of apprenticeships in North Carolina - over 1,000 in March 2025. Despite having a population of only 71,000, the Surry-Yadkin Works program has created a model for creating a strong workforce pipeline in a rural region.[1]

The Surry-Yadkin Works Apprenticeship connects high school students from Surry and Yadkin counties with internships and pre-apprenticeship opportunities in the region. The successes of the program are documented in a "playbook" developed in 2023, and provides steps for successful adaptation and replication of the program, funding sources, and best practices.



1. By comparison, Wake County is the largest county in the state with nearly 2 million

Figure D- 8. Surry-Yadkin Works Apprenticeship

11 2023-2024 ApprenticeshipNC Annual Report. https://wordpress.nccommunitycolleges.edu/wp-content/uploads/2024/12/ApprenticeshipNC-Annual-Report-FY-2023-2024.pdf

workdays at the partner company, and two taking coursework at RCC.

3.2.2 NCEdge

NCEdge is the first statewide customized training program of its kind in North Carolina, linking all 58 community colleges with businesses to deliver tailored workforce training. The program helps employees upskill, reskill, and acquire new skills, aligning closely with employer's needs. Services such as recruitment, candidate screening, and job-specific training are provided at no cost to qualified businesses, particularly in sectors like advanced manufacturing. NCEdge supports companies preparing for new processes, equipment upgrades, or expansion by ensuring their workforce is equipped with the necessary skills.[12]

3.2.1. NCWorks Certified Career Pathways

Local workforce boards use Certified Career Pathways (CCPs) to align training programs with the needs of their communities. Originating from the 2012 North Carolina Jobs Plan, CCPs are designed to integrate workforce development with secondary education and career planning. The NCWorks Commission oversees the certification process, and while Commerce is currently reviewing the criteria, the pathways have historically emphasized alignment with regional labor market demand, strong employer involvement, collaborative design by educators and industry, and integration with existing credentials to streamline learning. In 2019, six workforce development boards covering 21 counties implemented certified career pathways in energy. Many others have developed pathways in advanced manufacturing, which could serve as a foundation for building out complementary energy-related workforce initiatives.

3.2.2. Highlighted Industry Partnerships

The **North Carolina Battery Industry Partnership (NCBIP)** launched in January 2025 to bring together companies, educational institutions, and other key stakeholders to support the growing battery industry in North Carolina. Operated out of Appalachian State

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[12] *Rural Advanced Manufacturing Partnerships Toolkit: How North Carolina's Rural-Serving Community Colleges Leverage Partnerships to Meet Advanced Manufacturing Workforce Needs. NC Community Colleges. 2025. https://belk-center.ced.ncsu.edu/wp-content/uploads/sites/128/2025/05/RP3-Rural-Advanced-Manufacturing-Partnerships-Toolkit.pdf*

University, the group is working to support a wide range of goals for battery industry success including workforce development, safety and regulation, and policy.

EVeryone Charging Forward is a sectoral partnership between the North Carolina Business Center for Education and the North Carolina Community College system that addresses the training and education needs of the EV charging sector. The partnership will support the design of training and curriculum and develop pre-apprenticeships and registered apprenticeship programs in EV charging installation and maintenance and manufacturing occupations. NCBCE will partner with the Department of Public Instruction and local school districts to support high school Career and Technical Education departments to align their programs with new training.

AdvanceNC is a regional partnership between educational institutions, workforce development organizations, and major advanced manufacturing employers that have made investments in central North Carolina, such as Toyota and Wolfspeed. Created in September 2023, the initiative brings together 11 community colleges, three state universities, and seven local workforce development boards across 19 counties. AdvanceNC focuses on workforce recruitment, specialized training, awareness and engagement, and workforce retention.

3.2.3. Other Public-Led Efforts

Every five years, Commerce prepares a new strategic plan to guide the state's economic development priorities. The most recent plan, *First in Talent*, was adopted in 2021 and emphasized workforce readiness in response to the disruptions caused by the COVID-19 pandemic. Commerce staff are developing the next strategic plan, which is scheduled for completion by 2026. Energy is expected to be a key focus area in this plan, creating opportunities to integrate workforce initiatives from the CCAP into the state's broader economic development strategy.

3.3 Tools to Build a Climate Adaptation Workforce

In addition to the partnerships identified above, NC Commerce coordinates a suite of online tools used to support workforce development initiatives.

3.2.4. NCWorks Online

NCWorks Online is North Carolina's comprehensive workforce system portal, designed to connect jobseekers, employers, and workforce professionals across the state. Managed by

the NC Department of Commerce, it provides a centralized platform for individuals to search and apply for jobs, create resumes, explore career pathways, and access training opportunities. Employers can use NCWorks Online to post job openings, search for qualified candidates, and access labor market information. The system also integrates services from local NCWorks Career Centers, offering personalized assistance such as career counseling, skills assessments, and job readiness workshops. It also offers specialized support for veterans, youth, dislocated workers, and individuals with barriers to employment. Employers can use NCWorks Online to post jobs, screen applicants, and access labor market information, making it a central hub for workforce alignment across the state.

3.2.5. NCCareers.org

NCCareers.org is North Carolina's official online career information platform, providing students, job seekers, and educators with comprehensive tools for career exploration and planning. The site allows users to explore more than 800 occupations, assess their interests and values, compare wages and employment outlooks, and map out educational pathways aligned with their goals. It integrates real-time labor market data to ensure users have accurate and relevant information tailored to North Carolina's economy. NCCareers.org also serves as an educational resource for teachers and counselors, supporting career readiness and planning from middle school through adulthood.

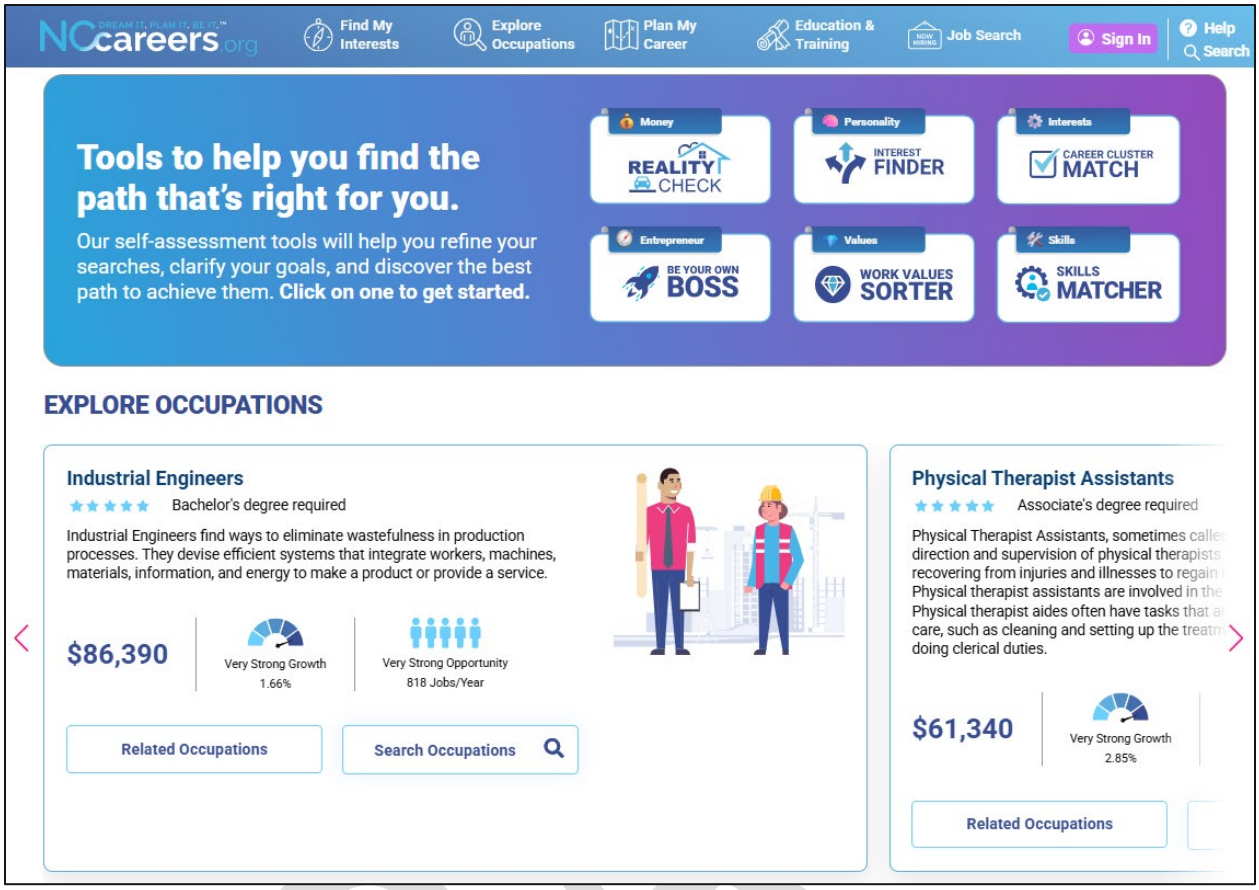

Figure D- 9. NC Careers.org Occupation Opportunities

3.2.6. Reality Check

Reality Check, a feature within NCCareers.org, is an interactive budgeting tool that helps users understand the relationship between lifestyle choices and income. Users begin by selecting the type of lifestyle they want — including preferences for housing, transportation, food, and entertainment — and Reality Check calculates the monthly expenses associated with those choices. The tool then suggests occupations in North Carolina that offer salaries capable of supporting that lifestyle, along with the education and training needed for each job. Reality Check is frequently used in classrooms and career counseling settings to introduce youth and adults to the financial realities of independent living and the importance of career planning.

3.3. Metrics for Measuring Workforce Development Outcomes

Commerce oversees a robust system for monitoring outcomes related to workforce development participation.

3.3.1. Common Follow-up System (CFS)

The North Carolina Common Follow-up System (CFS) contains a rich longitudinal database of information about participants in education and workforce programs, including employment, industry, and wage information. The program is managed by a partnership between Commerce's Labor and Economic Analysis Division (LEAD) and the North Carolina Government Data Analytics Center (GDAC). In 2025, data collection and analysis processes were improved to ensure a more accurate representation of the population served and alignment with the U.S. Department of Labor reporting requirements.

One application of this dataset is to track how many college graduates or workforce development participants enter industries critical to the clean energy transition. For example, the most recent 2025 data show that three out of every four individuals who find employment after completing the NC Community College's Customized Training program (NCEdge) go on to work in the manufacturing industry.

Table D- 10. Program Graduates and Participants from the Common Follow-up System 2019

Summary statistics for graduates and program participants from the Common Follow-up System (CFS) since 2019 by select programs[13]	WIOA Title 1 Adult Program	CTE Associate Degree Recipient	NCCCS Customized Training
Number of People Employed After Completing	18,762	57,971	49,184
Employment by Industry			
Wholesale Trade, Transport, and Utilities	15%	6%	13%
Construction	4%	5%	2%
Manufacturing	10%	9%	76%
Financial Activities	4%	4%	2%
Professional and Business Services	26%	16%	12%
Other Services	3%	4%	1%

[13] *The North Carolina Common Follow-Up System Evaluation Report. 2025. NC Department of Commerce. https://www.commerce.nc.gov/cfs-evaluation-report-2025/open*

3.3.2. LEAD Analytics

Commerce's Labor and Economic Analysis Division (LEAD) maintains a dashboard that tracks labor and workforce data for North Carolina and some subregions.[14] Common metrics include number of jobs by occupation and industry, wages, and demographic data.

3.3.3. myFutureNC Dashboard

In addition to the resources above, myFutureNC monitors progress of the educational attainment initiatives through a partnership with Carolina Demography.[15] A dashboard shows North Carolina's progress toward the state's overall 2030 goal of 2 million adults ages 25-44 with a postsecondary degree or credential. The dashboard also tracks 18 other educational metrics, including workforce alignment, a measure of how well the skills of graduates meet the needs of local employers.

[14] *LEAD Analytics: Dashboards & Data Access Tools* https://analytics.nccommerce.com/

[15] *myFutureNC Dashboard.* https://dashboard.myfuturenc.org/

Appendix E. Methodology for Quantifying GHG Reductions from Implementation Scenario Measures

This appendix outlines the approaches used to quantify GHG emission reductions for the CCAP measures. In some instances, NCDEQ conducted new analysis, and in others already modeled or quantified data was used. There are two measures that are not included in this approach because there were no actionable projects to include in the CCAP; they are VMT (Measure 4) and Industry (Measure 9).

1.1. Sector 1. Transportation Measures 1 - 4

1.1.1. Measure 1: MHD ZEV adoption

Quantified GHG Emission Reduction methods

DAQ utilized EPA's Diesel Emissions Quantifier[1] which evaluates clean diesel projects and upgrade options for medium-heavy and heavy-heavy duty diesel engines. Quantifier results for NO_X, $PM_{2.5}$, HC, CO and CO_2 are displayed in annual results (short tons) and lifetime results (short tons). Short tons are converted to metric tons by multiplying the number of short tons by 0.9071847 using the U.S. Energy Information Administration's guidance.[2]

Diesel Emissions Quantifier uses 'Remaining Life' to calculate lifetime emission reductions. Remaining life is the fleet owner's estimate of the number of years until the unit would have been retired from service if the unit were not being upgraded or scrapped, even if the unit were to be rebuilt or sold to another fleet. The remaining life estimate depends on the current age and condition of the vehicle at the time of upgrade, as well as things like usage, maintenance and climate. VW Phase 1 and Phase 2 projects that were awarded prior to March 1, 2024 that have not yet been completed are being included in this measure.

1.1.2. Measure 2: EV Infrastructure for LDV

Quantified GHG Emission Reduction methods

DAQ utilized Argonne National Laboratory's AFLEET Charging and Fueling Infrastructure (CFI) Emissions Tool. This tool estimates well-to-wheel greenhouse gas emissions and vehicle operation air pollutant emissions for proposals to the Federal Highway Administration's (FHWA) Charging and Fueling Infrastructure Discretionary Grant Program (CFI Program). The CFI Program covers electric vehicle charging, as well as hydrogen, propane, and natural gas fueling infrastructure. This tool was developed with the support of the Joint Office of Energy and Transportation, using the AFLEET Tool available at: https://greet.es.anl.gov/afleet. The AFLEET Tool uses emissions data from both the EPA's

[1] *EPA Diesel Emission Quantifier.* https://cfpub.epa.gov/quantifier/index.cfm?action=main.home

[2] U.S. Energy Information Administration's guidance https://www.eia.gov/tools/faqs/faq.php?id=7&t=2

MOVES and Argonne's GREET models. In accordance with FHWA's National Electric Vehicle Infrastructure Standards and Requirements [FHWA Docket No. FHWA-2022-008] in this tool, a charger is defined as "a device with one or more charging ports and connectors for charging EVs. Also referred to as Electric Vehicle Supply Equipment (EVSE)." VW Phase 1 and Phase 2 projects that were awarded prior to March 1, 2024 that have not yet been completed are being included in this measure.

1.1.3. Measure 3: Implement programs to increase efficiency and reduce GHG emissions at deep water and inland ports.

This measure aims to implement programs to improve energy efficiency associated with freight shipping across the State and lower emissions along the State's critical freight corridors that serve deep water and inland ports. These programs include upgrading technology at freight terminals and ports, expanding more efficient freight corridors across the state, and coordinating with private industry to increase electrification of equipment. GHG emission reductions for current programs are outlined in this section. Additionally, background information about Cost Benefits are described.

GHG reduction calculations approach

3-1. Intermodal Yard Improvements and Shipping Facility

This project accounts for diverting cargo moved by truck to rail. The CO_2 emission reductions calculated for this measure were estimated for 2025-2044 and held constant for 2045-2050. It is estimated that numbers of containers that could be shipped by rail would reach the 50,000 container rail movements per year capacity limit by 2040. Net emission reduction estimates were prepared for each year and summed to develop cumulative estimates for 2025-2030 and 2025-2050.

The incremental avoided CO_2 emissions for trucks was estimated using the total number of containers that could be diverted from trucks (one container per truck) to trains (200 containers/train for Charlotte and 234 containers/train for Rocky Mount) and the mileage from the Port of Wilmington to Charlotte (206 miles one way) or Rocky Mount (169 miles one way). Total truck miles diverted was multiplied by the CO_2 emission factor to estimate emissions. For truck container shipments to Charlotte, emissions were estimated incremental to existing shipments; therefore, container shipments diverted to train would not occur until 2036. The in-land port in Rocky Mount is new; therefore, container shipments diverted to train would start in 2025. The CO_2 emission factor for a heavy truck (1,646.77 grams CO_2 per mile) was multiplied by the total miles diverted from trucks to trains to estimate avoided CO_2 emissions (see U.S. Environmental Protection Agency, Emission Factors for Greenhouse Gas Inventories, Last Modified March 9, 2018, see Table 2).

The incremental increase in CO_2 emissions for trains was estimated using the total amount of incremental fuel that would be consumed by transporting containers diverted from trucks. The incremental fuel consumption was based on an estimate of the additional rail revenue ton miles using an average weight of the cargo per container (40 tons per train car), transport distance from the Port of Wilmington to Charlotte (206 miles one way) or Rocky Mount (169 miles one way), and number of containers transferred from trucks to trains. The Association of American Railroads reports rail fuel efficiency in 2018 at about 470 ton-miles of cargo hauled per gallon of fuel on average (see Association of American Railroads, The Environmental Benefits of Moving Freight by Rail, July 2019). The inverse of this value (0.00188 gallon per revenue ton mile) was multiplied by total revenue ton miles to estimate total fuel consumption. Total fuel consumed for both routes was then multiplied by a CO_2 emission factor for diesel fuel (10,180 grams CO_2 per gallon) to calculate the incremental increase in CO_2 emissions (see U.S. Environmental Protection Agency, Greenhouse Gases Equivalencies Calculator)

There are many other benefits associated with this measure including a net decrease in $PM_{2.5}$, NO_X, and SO2 emissions; travel time savings; and contributions to a decrease in on-road highway congestion, accidents, and fatalities.

3-2. NC Port Container Handler and Drayage Replacement

The project will replace cargo handling equipment with newer, more efficient equipment at the Port of Wilmington. The target fleet type is container handling equipment and terminal drayage trucks. The project will replace two (2) container handlers that are CARB/low NO_X certified, one (1) Class 8 non-DOT certified yard tractor, and three (3) Class 8 DOT Certified with VIN dray terminal trucks in Wilmington.

Emissions were calculated using the Diesel Emission Quantifier model for (5) container handlers and (4) yard tractors for the funding application; however, only (2) container handlers and (1) yard truck were funded. The total emissions reduced for lifetime of project were estimated to be 2,509 short tons CO_2. This estimate was divided by 3 to reflect the actual emissions and converted to $MTCO_2e$. Emissions related to idling from the (3) dray terminal trucks were not calculated because no information on the Port's current equipment operations and idle times was available and requires an idle-reduction policy to be put in place.

3-3 Pedestrian Safety Rail Bridge

The project will construct (1) an off-terminal parking facility for more than 250 employees and port users and (2) a pedestrian rail bridge (spanning six port railroad tracks) reducing GHG emissions by reducing VMT and also improving safety for employees and visitors.

Emissions were calculated using the EPA MOVES model emission factors for 2021, 2024 and 2027. VMT was estimated using annual average daily traffic counts and average miles traveled; 116 trips and 0.7miles respectively. The total emissions reduced is assumed constant over time because the project will be complete in 2027 and the number of vehicles in the offsite parking location will remain constant given the spaces allocated.

3-4 Modernization & Revitalization of Barge Berths

This project will rebuild the barge berths at the Port of Morehead City. GHG emission reductions were calculated for 2 different scenarios where either trucks or rail were used to haul the cargo in lieu of barge. The incremental avoided CO_2 emissions for trucks was estimated using the average VMT for trucks multiplied by the emission factor (1646.77 g CO_2/mile) and then converting to MT. The incremental avoid CO_2 emissions for rail was estimated using the VMT multiplied by the emission factor (10180 g/gallon diesel) and then converting to MT. The CO_2 emissions from the barge were removed from the total estimate. The total emissions reduced is assumed constant over time because no additional barges can be accommodated in this port.

Measure Costs

Each sub-measure estimated costs for implementation differently, therefore all sub-measure estimations are included below.

1. Intermodal Yard Improvements and Shipping Facility | A quantitative benefit-cost analysis (BCA)[1] was performed using available information about current truck drayage practices and current and proposed train operations, USDOT guidance, and supported by documentable costs and industry research data. The BCA is not a comprehensive measure of the project's total potential economic impact as regional benefits related to changes to the financial and workforce were not included. Future years' costs and benefits were projected, in constant dollars, for a period extending 20 years beyond construction which is approximately 2044.

Table E-1. Benefit Cost Summary (reproduced from Table 5 in the report[1])

Benefit or Cost Category		
Tot. Capital Cost including match @ 7% NPV		$18,184,207
Quantified Benefits @7% NPV:		
	Accident Reduction	$6,606,246
	Non-Carbon Emissions Reduction	$3,075,711
	Fuel Cost Savings	$8,235,014
	Social Cost of Carbon @3%	$5,296,877
Additional Savings:		
	Road Wear Savings	$5,589,267
	Reduced Highway Congestion	$26,183,412
	Consumer Transport Cost Reduction	$40,389,306
	Increased Inventory Holding Cost	($8,834,992)
Total Quantified Benefits		**$86,540,843**
Benefit to Cost Ratio (BCR)		4.8

2. Container Handler and Drayage Replacement | The primary costs for this sub-measure are for the purchase of 3 class 8 dray trucks and scrap disposal; purchase of one class 8 dray truck not DOT certified and scrap disposal; purchase of 2 container handlers and scrap disposal. The NC Port Authority is prepared to provide long-term operations and maintenance costs for these vehicles for their lifetime; however, those costs were not included in the documentation.

3. Pedestrian Safety Rail Bridge | A crucial element, the pedestrian rail bridge, will safely transport personnel across six active rail tracks, eliminating the risk of pedestrian-rail incidents. The primary costs for this sub-measure are for the construction of the pedestrian bridge; however, additional capital costs for this sub-measure include a dedicated shuttle service, pervious parking surfaces, solar panels to power the shuttle system and lighting. Benefits include reduction in VMT and mortality. The lifetime analysis corresponds to a 20-year benefit period until 2049.

Table E-2. Improved Benefits Summary (reproduced from Table 1 in the report[4])

Problems to be addressed	Changes to baseline	Type of Impact	Economic Benefit	Summary of results ($)[a]
Pedestrian facilities/bridge along project corridor lack dedication protection	Adding a secure and direct path into the port that allows workers to avoided queueing delays	VMT reduction/Idle time reductions	Pavement maintenance avoidance	26, 858
			Emissions costs savings	261,735
			Mortality reduction	17,041,557
			Noise reduction	38,945
		Longterm/Residual value	Facility improvement	329,541

[a] discounted at 3.1%

4.

Modernization & Revitalization of Barge Berths | The Benefit-Cost Analysis (BCA) for this project included three scenarios. The tables below describe the BCA for costs avoided for (1) diversion of dry cargo to both truck and rail and (2) diversion of dry cargo to truck only. These costs would be realized if the barge berths are not constructed.

Table E-3. Summary BCA Results – Truck and Rail Diversion of Dry Cargo (2022 dollars) – reproduced

Present Value	
Discounted Benefits	
Liquid Barge Depreciation Savings	$ 3,796,212
Avoided Vessel Congestion	$ 1,599,454
Liquid Barge Berth Cost Savings	$ 1,350,073
Liquid Cargo Supply Chain Savings	$ 243,590
Personnel Time Savings	$ 14,506,079
Truck/Freight Train Operating	$ 6,868,827
Safety Benefits	$ 508,408
Avoided External Highway Use	$ 6,167,010
Avoided Emissions	$ 20,278,922
Dry Barge Berth O&M Costs	($ 487,181)
Residual Value	$ 5,282,749
Total Discounted Benefits	$ 61,309,302
Discounted Costs	
Build Capital Costs	$ 17,450,878
Total Discounted Costs	**$ 17,450,878**
Benefit-Cost Ratio	3.53
Net Present Value	$ 44,069,645

Table E-4. Summary BCA Results – Truck Diversion of Dry Cargo (2022 dollars) – reproduced

Present Value	
Discounted Benefits	
Liquid Barge Depreciation Savings	$ 3,796,212
Avoided Vessel Congestion	$ 1,599,454
Liquid Barge Berth Cost Savings	$ 1,350,073
Liquid Cargo Supply Chain Savings	$ 243,590
Personnel Time Savings	$ 16,622,240
Truck/Freight Train Operating C Si	$ 5,509,723
Safety Benefits	$ 521,861
Avoided External Highway Use	$ 6,740,686
Avoided Emissions	$ 7,042,745
Dry Barge Berth O&M Costs	($ 487,181)
Residual Value	$ 5,282,749
Total Discounted Benefits	$ 49,528,488
Discounted Costs	
Build Capital Costs	$ 17,450,878
Total Discounted Costs	**$ 17,450,878**
Benefit-Cost Ratio	2.84
Net Present Value	$ 32,077,610

1.1.4. Measure 4: VMT – Unfunded

There are no projects or emissions calculated for the CCAP under this measure

1.2. Sector 2. Electricity Measures 5 and 6

1.2.1. Measure 5: Increase the amount of electricity generated by distributed and renewable resources in NC.

5-1 EnergizeNC

For the EnergizeNC calculation an assumed 43.4 MW of residential solar will be installed, as this is the lower bound of the program. This value was entered into NREL's PVWatts calculator for an estimated 60,372,493 kWh/year, the lifetime of the panels is assumed to be 25 years, resulting in a total of 1,509,312,325 kWh. To derive the amount of $MTCO_2e$, EPA's eGrid Emission Factor of 0.000303907 $MTCO_2e/kWh$, was used. This resulted in 18,348 $MTCO_2e$/year. The 2030 number is lower to reflect the rollout of the program, and the 2050 value has a higher range than calculated due to the potential for more installations.

5-2 Geothermal

The calculations and methods for this measure are included in Sector 3 – Commercial and Residential Buildings – Measure 8.

5-3 Timbermill Wind, LLC

At the current rate, Timbermill Wind is displacing 253,760 metric tons of carbon ($MTCO_2e$) annually. This displacement is anticipated to remain constant over the lifetime of the project (~30 years). This calculation was derived from using the EPA Avert tool (http://www.epa.gov/avert/download-avert) with the mid-Atlantic region data file assuming a 189 MW energy generating capacity from 45 wind turbines.

1.2.2. Measure 6: Microgrids for North Carolina Resilience

The microgrid calculation is based on estimates developed for the project application.

Table E-5. Number of Solar Units per kW PV for Microgrid

Number of units	kW Solar PV	Total kW	kWh LFP storage	Ave kWh LFP storage
5	20	100	10 - 50	30
20	50	1,000	50 – 100	75
50	100	5,000	50 – 200	125
2 (beehive)	5	10	n/a	n/a
Totals		**6,110**		**230**

The project estimated 6,100 kW solar PV with 110 kWh LFP storage and an additional 10 kW PV solar for the beehive system to be installed. NREL's PVWatts Calculator was used to estimate a total annual production of 8,658,477 kWh/year. The lifetime of the system was assumed to last 25 years. To derive the amount of $MTCO_2e$, EPA's eGrid Emission Factor of 0.000303907 $MTCO_2e/kWh$ was used. This results in 2,631.3 $MTCO_2e$ annually and 65,784.3 $MTCO_2e$ over 25 years.

1.3. Sector 3. Buildings - Residential and Commercial Measures 7 and 8

1.3.1. Measure 7: Reduce per square foot energy usage in residential buildings in NC

Overview

For each program in Measure 7, energy savings were estimated using available program data, regional building stock characteristics, and assumptions related to equipment lifetime and performance. Estimated energy savings were then converted into avoided GHG emissions using emissions factors shown in Table E-6.

Table E-6. GHG Emission Factors

Energy Source	Emission Factor	Units	Data Source
Electricity[a]	0.3039	$MTCO_2e/MWh$	NCDEQ (eGRID)
Natural Gas	53.115	kg CO_2e/MMBtu	EPA GHG Emission Factors Hub (2025)
Propane	61.703	kg CO_2e/MMBtu	
Fuel Oil No. 2	74.203	kg CO_2e/MMBtu	

[a] *The eGRID emission factor provided by NCDEQ was applied to all years from 2025 to 2050.*

Key components of the methodology and assumptions are described below.

Methodology

Program Rollout and Lifetime Assumptions

WAP measures were assumed to reach 1,945 homes per year from 2025 through 2050, based on the historical average of annual completions. An additional 600 homes per year were modeled under the WAP program from 2025-2029, reflecting funding through the Bipartisan Infrastructure Law (BIL). Measures funded through the HOMES and HEAR programs were assumed to be rolled out evenly over the period from 2025 to 2031. For all programs, installed measures were assumed to have a 15-year effective savings lifetime, with savings rolling off after this time period.

Whole-Home and Weatherization Measures

Applies to WAP, HOMES, and HEAR rebates for insulation, air sealing, and ventilation upgrades.

ICF derived statewide averages for annual North Carolina household energy consumption by fuel type using statewide averages from EIA's Residential Energy Consumption Survey (RECS), Table CE2.1.ST. Energy savings were then estimated as a percentage reduction in total household energy use based on program/market estimates and applied uniformly across fuels, including electricity, natural gas, and propane. These savings were subsequently converted to GHG emissions reductions using the emissions factors listed in Table 1.

Appliance-Level Measures

Applies to HEAR rebates for heat pumps, heat pump water heaters, heat pump clothes dryers/washers, and electric ranges/stovetops.

ICF derived statewide averages for annual household energy consumption by fuel type and end-use using RECS microdata. For each end-use listed in Table E-7, baseline equipment distributions in North Carolina's residential building stock were estimated using NREL's ResStock 2024.2 dataset.

NCDEQ provided assumptions regarding the total number of rebates available for each project type (Table E-8). These rebates were then allocated proportionally according to the baseline distribution of existing technologies. For instance, 18% of NC water heating systems in the baseline stock are gas-fired, 77% are electric resistance, and 4% are propane-fired. It is assumed then that 18% of rebates for heat pump water heaters would replace gas units, 77% would replace electric units, and 4% would replace propane units.

Table E-7. Distribution of Baseline Equipment by End Use and Fuel

End Use	Natural Gas	Electric	Propane	Fuel Oil
Space Heating	22%	23%[a]	7%	3%
Cooling	N/A	100%	N/A	N/A
Water Heating	18%	77%[a]	4%	N/A
Clothes Dryer	2%	85%[a]	1%	N/A
Cooking	14%	81%	6%	N/A

[a] *Baseline equipment is electric resistance, reflecting with program requirements.*

Note: Remaining space heating equipment is comprised primarily of heat pump technologies

Table E-8. Distribution of HEAR Rebates by Baseline Equipment

End Use	Project Type	Total Rebates	Rebates by Baseline Equipment			
			Gas	Electric	Propane	Fuel Oil
Space Heating	Heat pump for space heating/cooling	5,742	2,294	2,391[a]	746	311
Cooling		5,742[b]	N/A	5,742	N/A	N/A
Water Heating	Heat pump water heater	6,294	1,159	4,903[a]	232	N/A
Clothes Dryer	Heat pump dryer	3,520	93	3,392	35	N/A
Cooking	Electric stove	1,482	1,047	N/A[c]	435	N/A

[a] Baseline equipment is electric resistance.
[b] According to EIA RECS, 91% of homes in NC have existing AC systems. ICF therefore assumes that 91% of homes receiving heat pump rebates will see energy savings from improved cooling efficiency. The remaining 9% are assumed to add new cooling load, leading to increased electricity consumption.
[c] Rebates are not available for electric-to-electric conversions.

Measure-specific energy savings (e.g., gas water heater to heat pump water heater) were estimated using a combination of sources, including NREL's Residential Measures Database, EIA's 2023 Technology Forecast Updates, and a review of available literature. These savings were multiplied by the number of projected upgrades listed in Table 3 to calculate total energy savings by fuel and project type. Energy savings were subsequently converted to GHG emissions reductions using the emissions factors listed in Table 1. Note that upgrades related to wiring and electric load service centers were excluded from the analysis, as their impact on energy consumption is indirect and not quantifiable in terms of GHG reductions.

Program-Specific Assumptions

Weatherization Assistance Program (WAP)	
Program Description	WAP provides weatherization services (e.g., insulation, air sealing, ventilation) to low-income households, funded through the U.S. Department of Energy (DOE) and the North Carolina Department of Health and Human Services (DHHS).
Program Participation	1,945 homes upgraded annually from 2025 through 2050, based on average completions between 2020 and 2024. An additional 600 homes are also modeled as upgraded annually from 2025-2029 through one-time funding from the BIL.
Total Homes Upgraded	53,570
Rollout Period	2025-2050
Savings Assumption(s)	15% reduction in total household energy consumption per home, applied proportionally across fuels. This value is based on national WAP statistics, which show typical savings ranging from 7-18%.[3]

Homeowners Managing Efficiency Savings (HOMES)	
Program Description	HOMES provides rebates for whole-home energy efficiency improvements. A total of $68 million is allocated to direct rebates, with a maximum rebate of $16,000 per household.
Program Participation	4,250 total homes upgraded statewide, evenly distributed across the years 2025–2031.
Total Rebates Provided	4,250
Rollout Period	2025-2031
Savings Assumption(s)	20% reduction in total household energy use per upgraded home, applied proportionally across fuels. This aligns with the minimum program requirement.

[3] *U.S. DOE (2015). National Evaluation of the Weatherization Assistance Program.* https://www.energy.gov/sites/prod/files/2015/08/f25/WAP_NationalEvaluation_WxWorks_v14_blue_8%205%2015.pdf

Home Electrification and Appliance Rebates (HEAR)	
Program Description	HEAR provides $74 million in rebates for energy-efficient electric appliances and related upgrades.
Program Participation	Rebate counts by project type were estimated based on assumptions provided by NCDEQ. Rebate deployment was assumed to be evenly distributed across the years 2025–2031.
Total Rebates Provided	23,332 [a]
Rollout Period	2025-2031
Savings Assumption(s)	Measure-specific energy savings were estimated using a combination of sources, including NREL's Residential Measures Database, EIA's Technology Forecast Updates, and a review of available literature.

[a] *Excludes rebates for electric load service centers and electric wiring.*

1.3.2. Measure 8: Decarbonizing public buildings in NC.

To calculate avoided emissions resulting from the Utility Savings Initiative (USI), the following methodology was applied. Since the program's inception in 2001, most state agencies have reported annual energy consumption and building square footage. By 2005, reporting expanded to include University of North Carolina (UNC) institutions and the North Carolina Community College System. Using this data, the USI calculates annual Energy Use Intensity (EUI) using the formula:

EUI = Total Energy Use (BTUs) / Total Square Footage

Each year, the current EUI is compared against the baseline year of 2001–2002 to assess progress toward the legislated energy reduction goal of 40% by 2025. Based on historical trends, EUI values were graphed against time to estimate the year in which this reduction target would be met. For forecasting purposes, square footage was held constant from 2025 to 2050, and energy usage was normalized across all fuel types.

To align with CPRG (Climate Pollution Reduction Grant) guidelines, the 2005 baseline year was used to ensure consistency with Business-As-Usual (BAU) projections. For each

reported fuel type—electricity (kWh), natural gas (therms), No. 2 oil (gallons), No. 6 oil (gallons), and propane (gallons)—fuel-specific Energy Intensity (EI) was calculated:

EI (Fuel Type) = Fuel Use / Square Footage

These EI values were plotted over time, and future EI values for each fuel type were extrapolated annually through 2030–2031, after which they were held constant through 2050. Projected fuel use was then back-calculated using these EI values and assumed square footage.

Greenhouse gas (GHG) emissions were estimated using published emissions coefficients for each fuel type. In the case of electricity, annual coefficients were adjusted to reflect grid decarbonization in North Carolina. Emissions were calculated as follows:

Actual Emissions = Fuel Use × Emissions Coefficient (Year/Fuel Type) Baseline Emissions (2005) = Fuel Use (2005) × Emissions Coefficient (2005) Avoided Emissions = Baseline Emissions − Actual Emissions

Avoided emissions were calculated annually for each fuel type and aggregated using:

Total Avoided Emissions (2005–HY) = ∑ Avoided Emissions by Year and Fuel

Finally, avoided emissions across all fuel types were summed to determine total avoided emissions attributable to the USI program for horizon years (HYs) 2030 and 2050.

1.4. Sector 4. Industry Measure 9

1.4.1. Measure 9: Unfunded

There are no projects or emissions calculated for the CCAP under this measure

1.5. Sector 5. Waste Measures 10 - 12

1.5.1. Measure 10: Reduce food waste.

Avoided emissions from food diversion programs were calculated from data collected through research of existing food collection programs, surveys, and interviews of experts in the waste industry. There are 24 locations in the state that collect food through composting or recovery programs at schools, cities and counties. The GHG reduction was determined based on a weight basis (tons/year) using EPA's Waste Reduction Model (WARM).

Data was collected in pounds per year for compost and recovery programs resulting in 23,450.1585 short tons and 330,188.516 short tons respectively. Using WARM EFs for compost and recovery (1.55 $MTCO_2e$/short ton and 3.66 $MTCO_2e$/short ton) our 25-year GHG reduction goal for this measure is 30,300,187 $MTCO_2e$.

1.5.2. Measure 11: Decarbonize waste collection.

The calculation of GHG emission reductions for this measure are included in the Transportation Sector Measure 1. Please refer to that section for methodologies.

1.5.3. Measure 12: Reduce landfill gas emissions.

It is estimated that GHG reduction benefits may be on the order of 300 to 600 tons per year of CO_2e, per acre of transitional cover installed, over a ten-year period (~4500 tons/acre). Considering the decrease in the landfill gas over time the annual GHGs reductions were calculated to be ~4500 tons/acre to account for field conditions. The use of more robust covers, prior to closure, at multiple landfills across NC with a total application of 200 acres over 25 years.

1.6. Sector 6. Natural and Working Lands Measures 13 and 14

This section summarizes methodologies and estimates for greenhouse gas benefits from natural climate solutions in coastal and forestry projects. The entire Technical Appendix is not included here and refers to the ACC grant application refers to all ACC projects, including those in MD, VA and SC. The GHG benefit estimates included in the NWL part of the CCAP are for the NC projects, and the methodology below was used to calculate those estimates.

1.6.1. Measure 13: Coastal Habitat Enhancement and Peatlands Restoration

GHG benefits from coastal habitat peatlands are estimated based on proposed project area and per-acre GHG benefits from scientific literature. Implementation assumptions vary by geography and project type, with a primary assumption that projects will stay within budget. Additionally, coastal marshes have carbon stocks of 298.30-415.11 $MTCO_2e$/acre, with ongoing benefits of 1.55-4.23 $MTCO_2e$/acre/year. The average annual

carbon benefit of this measure was estimated by dividing the total carbon benefit for this measure by the number of years over which this benefit accrues. The annual carbon benefit is estimated to be 468,107.9 $MTCO_2e$/year for the period 2025-2030 and 768,635.3 $MTCO_2e$/year for the period 2025-2050. Total carbon benefit is estimated at 2,340,539.4 $MTCO_2e$ from 2025-2030 and 19,215,883.2 $MTCO_2e$ from 2025-2050.

1.6.2. Measure 14: Protect, use, and develop agricultural and forest land

GHG benefits from forestry projects are categorized into improved forest management, reforestation, urban tree planting, and avoided forest conversion. Per-acre estimates for GHG benefits are calculated using various data models and methodologies specific to each project type. The primary activity data used to track progress across project types include acres conserved, acres reforested, and number of trees planted. The annual carbon benefit was estimated by dividing the total carbon benefit for this measure by the number of years over which this benefit accrues. Total carbon benefit is estimated at 1,021,710.0 $MTCO_2e$ from 2025-2030 and 8,811,294.8 $MTCO_2e$ from 2025-2050.

Appendix F. Caveats and Limitations

This appendix outlines the caveats and limitations of models or approaches used to quantify GHG emission reductions outlined in Appendix E.

1.1. Models

1.1.1. Alternative Fuels Data Centers Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite

EVI-Pro Lite is an online tool for projecting consumer demand for electric vehicle (EV) charging infrastructure. The EVI-Pro Lite tool uses simulations to predict the type and quantity of charging infrastructure required to support different levels of EV adoption. Simulations use data on charging station characteristics, EV attributes, and personal vehicle travel patterns. The EVI-Pro Lite tool gives users the option to change assumptions about vehicle mix and electricity needs and provides planners with suggested infrastructure priorities. The tool includes projections for home charging versus public charging. EVI-Pro Lite is a simplified version of the Electric Vehicle Infrastructure Projection Tool (EVI-Pro) housed in the Alternative Fuel Toolkit[1]. EVI-Pro was developed collaboration between the National Renewable Energy Laboratory and the California Energy Commission, with additional support from the U.S. Department of Energy's Vehicle Technologies Office. The Alternative Fuel Toolkit is an online platform designed to help state Departments of Transportation (DOTs) learn more about alternative fuels, plan alternative fuel vehicle infrastructure and explore funding sources, and take action to deploy alternative fuels and vehicles using an online action guide, set of facilitation materials, and other resources. The website[2] is the result of an effort led by the Oregon DOT and FHWA and supported by nine other state DOTs.

Limitations to Consider:

- EVI-Pro Lite is useful for basic estimations, it may not be suitable for comprehensive assessments of electric vehicle infrastructure needs.
- EV hardware and installation cost parameters have been developed purely based on historic observations compiled from literature.[3]
- EVI-Pro Lite is best used for estimating daily charging needs in urban planning.
- EV-Pro lite also does not allow for custom travel behavior modeling because a user cannot input local travel survey data or customize trip patterns.
- EV-Pro Lite is also not suitable for fleet operations, medium- or heavy-duty EVs, and depot charging estimates.
- The model assumes most drivers will charge at home.

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[1] *Alternative Fuel Toolkit https://www.nrel.gov/transportation/evi-pro.html*
[2] *Link: http://altfueltoolkit.org/*
[3] *https://docs.nrel.gov/docs/fy23osti/85654.pdf*

1.1.2. AFLEET CFI Emissions Tool

The AFLEET CFI Emissions Tool estimates well-to-wheel GHG emissions and vehicle operation air pollutant emissions for the FHWA Charging and Fueling Infrastructure Discretionary Grant Program (CFI Program). The CFI Program covers EVs charging, as well as hydrogen, propane, and natural gas fueling infrastructure. This tool was developed with the support of the Joint Office of Energy and Transportation, using the AFLEET Tool.[4] The AFLEET Tool uses emissions data from both the EPA's MOVES (Motor Vehicle Emission Simulator) and Argonne's GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies) models.

These limitations highlight the need for users to consider the tool's limitations when using it for detailed assessments and to ensure the results are as accurate as possible.

Limitations to Consider:

- Simplistic Inputs: The tool requires simple inputs, which may not fully capture the complexity of vehicle and fuel choices.
- Limited Data for Off-Road Vehicles: The tool does not provide detailed data for off-road vehicles, which may be necessary for comprehensive assessments.
- Exclusion of Idle Reduction: The tool does not account for idle reduction strategies, which can significantly impact fuel efficiency and emissions.
- Limited Customization: The tool's customization options are limited, which may not accommodate all user-specific needs.
- Potential for Bias: The tool's reliance on user input may introduce potential biases, affecting the accuracy of the results.

1.1.3. The Federal Highway Administration (FHWA) Office of Natural Environment developed the Congestion Mitigation and Air Quality Improvement (CMAQ) Emissions Calculator Toolkit

The purpose of the Congestion Mitigation and Air Quality Improvement Program Emissions Calculator Toolkit (CMAQ Toolkit)[5] is to provide users a standardized approach to estimating emissions reductions from the implementation of a CMAQ-funded project. The CMAQ Toolkit uses emissions rates based on national-scale runs of the Motor Vehicle Emission Simulator (MOVES) as well as other data sources. For each tool in the toolkit, the

[4] *AFLEET Tool https://greet.es.anl.gov/afleet*
[5] *https://rosap.ntl.bts.gov/view/dot/35982*

inputs and methodology are described in user guides along with some example cases. Information regarding the development of default emissions rates and guidance on incorporating user-supplied emissions rates can be found in the accompanying Emissions Data documentation.

The FHWA has developed a CMAQ Emissions Calculator Toolkit which is located on the FHWA CMAQ Website.[6] This collection of spreadsheet-based tools allows users to estimate emission reduction for many CMAQ project types. It is offered as an additional resource to assist DOTs, MPOs and project sponsors in the project justification and reporting process.

Limitations to Consider:

- Emissions estimates from the CMAQ Toolkit are not intended to meet specific requirements for State Implementation Plans (SIPs) or transportation conformity analyses.
- The toolkit uses default emission rates based on MOVES (Motor Vehicle Emission Simulator) runs which provides county-level results, therefore, they may not reflect local conditions unless users input custom data.
- Each module (e.g., Intersection Improvements, Diesel Retrofit) is designed for specific project types. Applying a module outside its intended scope can lead to inaccurate results.
- Emissions are typically calculated for peak and off-peak hours on a typical weekday, which may not capture seasonal or long-term variations.
- CMAQ relies on pre-processed traffic data rather than real-time traffic flow.It does not account for dynamic traffic conditions (accidents, construction) unless those are reflected in the emissions inventory. CMAQ allows the user to receive emissions data on an hourly, daily, monthly, and annual basis. Currently, the most recent emissions inventory for CMAQ dates to 2019. While there are separate cost-effectiveness tables, the toolkit itself does not integrate cost analysis directly into its emissions estimates.
- The tool relies on various input data (emissions, meteorological data, etc.) thus the quality, availability, accuracy, and up-to-date nature of the data may be a limitation. CMAQ's accuracy heavily depends on the quality of emissions data. Inaccuracies in inventories (underreporting of mobile or industrial sources) can lead to biased results. The tool is updated by the EPA every 1-2 years; however, these updates rely on receiving accurate and current data from sources. Furthermore, peer reviews have noted that model evaluation is often limited to specific time periods or regions, which may not fully capture seasonal or interannual variability

[6] *https://rosap.ntl.bts.gov/view/dot/35982*

1.1.4. NREL's PVWatts calculator

The PVWatts[7] calculator estimates the energy production and energy cost of grid-connected photovoltaic (PV) energy systems worldwide. It allows homeowners, small building owners, installers, and manufacturers to easily develop estimations of the performance of potential PV installations. The tool is available free of charge and without a prior registration.

Limitations to Consider:

- It is not possible to run PVWatts® using your own solar resource data file or a data from a source other than those discussed here. The online version of PVWatts® (hosted by NREL) is designed for ease of use, but it limits users to predefined solar resource datasets like TMY2 or TMY3, where TMY stands for typical meteorological year. As a result, this tool is not appropriate for individual residential estimates due to un-customizable load profiles and generic weather data and simplified system input. If you want to run PVWatts® simulations with your own solar resource data file, you can use the version of PVWatts® in NREL's System Advisor Model (SAM). SAM allows the user to upload their own solar resource data.
- Solar resource data sources for locations not covered by the National Solar Radiation Database (NSRDB) include:
    - Solar and Wind Energy Resource Assessment Programme (SWERA)
    - The ASHRAE International Weather for Energy Calculations Version 1.1 (IWEC)
    - Canadian Weather for Energy Calculations (CWEC)
- The NSRDB for PVWatts is a special set of files from the NSRDB. These files were collected from the following NSRDB datasets:
    - PSM V3 TMY (tmy-2020)
    - Himarawi PSM V3 TMY (tmy-2020)
    - Meteosat Prime Meridian V1.0.0 TMY (PSM V4, tmy-2022)
    - PVWatts does not account for complex shading scenarios (e.g., trees, buildings, terrain). It assumes uniform irradiance across the array, which can lead to overestimation of energy production and costs in shaded environments.
    - The model cannot model multiple array orientations or tilt angles. Only supports basic system types (fixed, single-axis tracking, roof-mounted).
    - The model Uses an average default system loss of 14%, which may not reflect real-world conditions. High-performance systems might have losses closer to 10–12%, while poorly maintained or complex systems could exceed 16–20%.

[7] https://pvwatts.nrel.gov/

- The model Lacks capabilities for modeling financial incentives, depreciation, or detailed cash flow. For in-depth financial analysis, tools like SAM (System Advisor Model) or PVsyst are recommended.
- While recent versions use improved weather data (e.g., NSRDB PSM V3 with 4 km resolution), microclimate effects and local anomalies may still be missed. The tool does not differentiate between high-efficiency and lower-performing PV modules. The model treats all modules as having similar performance characteristics. Typical accuracy ranges are ±10% annually for well-matched systems, but results can vary significantly based on site-specific factors like shading, soiling, and microclimate conditions that aren't captured in the standard modeling. The 14% default system loss may not reflect your installation – premium systems with excellent maintenance might see 10-12% losses, while challenging installations could experience 16-20% losses, requiring input adjustments for accurate estimates

- For more advanced modeling, especially for commercial-scale or complex residential systems, PVWatts should be complemented with tools like SAM or PVsys.

1.1.5. EPA's eGrid

The Emissions & Generation Resource Integrated Database (eGRID)[8] is a comprehensive source of data from EPA's Clean Air Power Sector Programs on the environmental characteristics of almost all electric power generated in the United States.

The data includes emissions, emission rates, generation, heat input, resource mix, and many other attributes. eGRID is typically used for greenhouse gas registries and inventories, carbon footprints for electricity purchases, consumer information disclosure, emission inventories and standards, power market changes, and avoided emission estimates.

Limitations to Consider:

- Data Aggregation Levels: eGRID reports data at various levels of aggregation, which may limit the granularity of the data for specific analyses.
- Data Source Limitations: There can be outliers in output emission rates, which may not reflect the typical behavior of the data. The eGRID tool relies on data from EPA's Clean Air Markets Division (CAMD) and EIA Forms 860 and 923, which may have: incomplete or inconsistent reporting, differences in reporting thresholds and methodologies, and gaps for smaller or non-grid-connected generators.

[8] *https://www.epa.gov/egrid*

- Methodological Changes: The methodology for assigning electricity generating plants to eGRID subregions has changed, which may affect how data is interpreted and used. Emissions are attributed based on plant-level averages, not real-time dispatch or marginal generation, which can misrepresent emissions from specific electricity usage.
- Limited Historical Data: The dataset may not cover all years or may have limitations in terms of data availability. The tool only provides annual data, hourly data cannot be provided. eGRID includes data for the following years:
    - 1996 through 2000
    - 2004, 2005, 2007, 2009, 2010, 2012, 2014, 2016
    - Annually from 2018 through 2023
    - eGRID is typically released annually, but the data reflects conditions two years prior to the release year. For example, eGRID2023 (with 2023 data) was released in January and June 2025. The next planned release(eGRID2024) is scheduled for January 2026

1.1.6. EPA Simplified GHG Emissions Calculator

The EPA Simplified GHG Emissions Calculator ("the Calculator")[9] is a free tool that is designed as a simplified calculation tool to help organizations estimate annual greenhouse gas (GHG) emissions.The Calculator quantifies direct and indirect emissions based on user input for a specific source. All methodologies and default values provided are based on the most current Center for Corporate Climate Leadership Greenhouse Gas Inventory Guidance Documents and the Emission Factors Hub.

Limitations to Consider:

- The tool is intended for small to medium sized organizations who are in the early stages of GHG management.
- The calculator provides *approximate estimates* and is not suitable for official emission inventories or rigorous carbon accounting. It's designed for communication and educational purposes, not regulatory compliance.
- Not all energy units are provided in the calculator. As a result, if energy data is in units not used in the EPA's calculator, prior unit conversion to units provided in the calculator will need to be completed before using the tool to calculate GHG emission reductions. For example, BTU units are not included in the calculator and thereby must be converted to therms (or the desired unit utilized in the EPA's GHG Emissions Calculator) before the model can be used.

[9] *https://www.epa.gov/climateleadership/simplified-ghg-emissions-calculator*

- The calculator uses average emission factors for electricity, which may not reflect real-world variations in energy sources or grid mix. As a result, this may lead to over or underestimates of GHG emissions. While the tool allows users to select subregions, it still generalizes emissions across that area. Local utilities with cleaner portfolios (e.g., hydro-heavy or nuclear) may have much lower emissions than the regional average.
- The calculator focuses on a narrow set of inputs—like gasoline, electricity, and natural gas—and may not accommodate more complex or diverse energy/emissions scenarios.
- The calculator assumes fixed values for things like vehicle emissions or energy consumption, which may not reflect technological changes, behavioral shifts, or policy updates.

1.1.7. EPA's Waste Reduction Model (WARM)

The Waste Reduction Model (WARM)[10] is a tool created by the U.S. Environmental Protection Agency (EPA) to help solid waste planners and organizations estimate greenhouse gas (GHG) emission reductions and economic impacts from several different waste management practices. The tool calculates and totals the GHG emissions, energy savings and economic impacts of baseline and alternative waste management practices, including source reduction, recycling, combustion, composting, anaerobic digestion and landfilling.

Limitations to Consider:

- WARM is a screening level tool, best used for providing site managers data on how to reduce GHG emissions that may inform management decisions. It is not a comprehensive tool for developing a GHG inventory.
- Lack of Variation in Transportation Distances: The model does not account for variations in transportation distances, which can lead to inaccurate emissions estimates for decentralized operations. The default transportation distances in WARM are listed below:
  - Landfilling:
    - Default distance: **20 miles**
    - Assumes waste is transported by **diesel truck**
  - Combustion (Waste-to-Energy):
    - Default distance: **20 miles**
    - Also assumes diesel truck transport

[10] https://www.epa.gov/waste-reduction-model

    - Recycling:
        - Default distance: **500 miles**
        - Reflects longer hauls to regional or national recycling facilities
    - Composting:
        - Default distance: **20 miles**
    - Anaerobic Digestion:
        - Default distance: **20 miles**
- Static Emission Factors: Relies on national averages and static lifecycle data, which may not reflect regional variations, technological advancements, or local waste management practices.
- Limited Material Scope: While WARM covers many common materials (e.g., paper, plastics, metals, organics), it doesn't include all waste types (especially niche or emerging materials like textiles, hazardous waste, or electronics in detail).
- Need for Site-Specific Information: The model requires site-specific information to provide more accurate results, which may not always be readily available.
- Limitations in GHG Inventory Development: WARM is not designed for developing GHG inventories.

1.1.8. Diesel Emission Quantifier (DEQ)

EPA's Diesel Emissions Quantifier[11] is a tool to help fleet owners, school districts, municipalities, contractors, port authorities, and others estimate cost effectiveness and environmental impact of emission reduction technologies that have been added to medium- and heavy-duty diesel vehicles and equipment. Estimates are made using specific information about a fleet, such as miles driven, miles per gallon, and others. Also included are health benefits cost analysis for reduced emissions and alternative options for vehicle replacement or upgrades.

Limitations to Consider:

- Vehicle Type: The Diesel Emissions Quantifier primarily calculates emission reductions for medium- and heavy- -duty vehicles, not for light-duty vehicles.
- Default Values: The Diesel Emissions Quantifier uses default values for certain data affecting emissions, such as temperature and humidity, which may not account for all factors in real-world scenarios.
- Fuel Savings: The Diesel Emissions Quantifier does not provide information on fuel savings or estimates, focusing solely on CO_2 emission reductions.

[11] https://cfpub.epa.gov/quantifier/index.cfm?action=main.home

- Technology Entry: The Diesel Emissions Quantifier may not be suitable for all technology options, as it is designed for specific retrofit projects and does not support all types of emissions reduction technologies.

1.1.9. Baseline Resilience Indicators for Communities (BRIC)

The Baseline Resilience Indicators for Communities (BRIC)[12] describes the differences in community resilience among counties within the state and within the nation through a comparative community resilience score. BRIC is comprised of six broad categories of community disaster resilience. Used as an initial baseline for monitoring existing attributes of resilience to natural hazards, BRIC can be used to compare places to one another, to determine the specific drivers of resilience for counties, and to monitor improvements in resilience over time. BRIC helps communities: assess their baseline resilience to natural hazards, identify strengths and vulnerabilities across key domains, compare resilience across counties and track changes over time (2010, 2015, 2020). It's especially useful for emergency planners, public health officials, and policy makers allocating resources and preparing for disasters.

BRIC considers six broad categories of community disaster resilience: Cultural/Social, Economic/Financial, Built Environment/Housing, Institutional/Governance, Community Capacity, Environmental/Natural.

Limitations to Consider:

- This index utilizes uniform formulas and variables across the coverage area; it does not consider community-specific variables. The interpretation is limited to the variable included in the analysis.
- BRIC provides a baseline view, often based on data from specific years (e.g., 2010, 2015, 2020). It doesn't capture real-time changes or dynamic shifts in resilience due to recent events or policy changes.
- Relies heavily on publicly available federal datasets, which may be outdated or incomplete. Many of data sets utilized include: OpenFEMA Hazard Mitigation Assistance (HMA) Datasets, FEMA's National Risk Index (NRI), Social Vulnerability Index (SoVI), Expected Annual Loss (EAL), FEMA Data Hub, and the American Community Survey.
- Some indicators may not be uniformly reported across all counties, affecting comparability. Certain counties may lack reliable data for certain indicators due to limited resources, outdated reporting systems, or small population sizes. For

[12] https://experience.arcgis.com/experience/376770c1113943b6b5f6b58ff1c2fb5c/page/BRIC/

example, rural counties might not report detailed health or infrastructure metrics, skewing their resilience scores.

- Aggregates data at the county level, potentially masking intra-county disparities. BRIC may overlook hyper-local factors like neighborhood-level social cohesion or informal networks.
- Uses a "capitals" approach (social, economic, institutional, infrastructural, environmental, and community capital), but the weighting of indicators can be subjective.
- Principal component analysis or other statistical methods may not reflect community priorities or lived experiences.
- BRIC is better at describing existing conditions than predicting future resilience or outcomes. It doesn't directly measure how communities respond to actual disasters or recover over time.
- Environmental indicators may not fully capture climate change vulnerabilities or ecological resilience. Some natural hazard risks (e.g., wildfire, drought) are underrepresented depending on the region.

1.1.10. Communities Advancing Resilience Toolkit (CART)

The Communities Advancing Resilience Toolkit (CART)[13] is a tool that uses surveys to determine the strengths and weaknesses of a community regarding their involvement in disaster prevention, mitigation, and recovery. The surveys can help establish a baseline about a specific community thereby informing public health professionals of resources that will be required to help the community recover. Public health professionals seeking tools to assess community demographics and resilience can use this resource. It helps evaluate strengths and weaknesses, focusing on community involvement for disaster prevention, mitigation, and recovery. CART surveys may be used to obtain baseline information about a community in order to identify its strengths and challenges, and to evaluate a community after a disruptive event or post intervention.

- CART allows users to create an assessment survey of a community's response to disaster by:
    - Measuring resilience across five key domains:
        - Connection and Caring
        - Resources

[13] https://www.atsdr.cdc.gov/community-stress-resource-center/php/resources/cart-integrated-system.html#:~:text=Public%20health%20professionals%20seeking%20tools%20to%20assess%20community,community%20involvement%20for%20disaster%20prevention%2C%20mitigation%2C%20and%20recovery.

        - Transformative Potential
        - Disaster Management
        - Information and Communication
    - Using a 5-point Likert scale to gauge community perceptions and experiences.
    - Organizations can add questions tailored to local concerns or specific populations.
    - Encouraging community participation in both design and interpretation of results.
    - Combining survey data with demographic and contextual information to provide a holistic snapshot of community resilience.
    - Supporting long-term planning, community engagement, and informal outreach mechanisms.

Limitations to Consider:

- The tool measures the perceptions of community members, it does not provide an externally-based, objective measure of a community's resilience.
- No Hazard-Specific Metrics: Focuses on general resilience capacity, not specific risks like floods, wildfires, or pandemics.
- Surveyor and Responder Bias: The questionnaire was administered via interviews. The toolkit relies heavily on self-reported survey responses, which can introduce bias or inaccuracies depending on participants' perceptions, literacy levels, or willingness to respond honestly. While inter viewer and/or responder bias cannot be ruled out, trained interviewers were considered by the sponsoring organization to be sufficiently qualified that they were used to conduct structured interviews for subsequent neighborhood surveys.
- Implementing CART effectively requires time, trained personnel, and community engagement. Disadvantaged communities may struggle with these demands, limiting the toolkit's reach and impact.[14]

1.1.11. EPA Landfill Methane Outreach Program (LMOP) Tool

The EPA's Landfill Methane Outreach Program (LMOP)[15] is a voluntary initiative that promotes the reduction of methane emissions from landfills by encouraging the recovery

[14] *Citation: Pfefferbaum RL, Pfefferbaum B, Zhao YD, Van Horn RL, McCarter GS, Leonard MB. Assessing community resilience: A CART survey application in an impoverished urban community. Disaster Health. 2016 May 13;3(2):45-56. doi: 10.1080/21665044.2016.1189068. PMID: 28229014; PMCID: PMC5314893*

[15] *https://www.epa.gov/lmop/list-tools-related-landfill-gas-and-waste-management*

and beneficial use of landfill gas (LFG). LMOP provides a suite of tools and resources to support project development, feasibility analysis, and stakeholder collaboration.

LMOP forms partnerships with communities, landfill owners and operators, utilities, power marketers, states, project developers, Tribes and nonprofit organizations to overcome barriers to project development. LMOP focuses on LFG energy project development at MSW landfills, the largest source of methane emissions from the waste sector.

LMOP activities include:

- Providing technical assistance, guidance materials and software to assess the potential economic feasibility of an LFG energy project.
- Developing informational materials about the benefits of renewable energy from biogas generated from MSW, as well as opportunities to reduce emissions from existing MSW landfills.
- Fostering partnerships and identifying financing for biogas projects.
- Creating networking opportunities with peers and renewable energy experts

Key Tools and Capabilities of the LMOP Toolset

1. LFGcost-Web
    - A Microsoft Excel-based tool that estimates the economic feasibility, environmental benefits, and job creation potential of landfill gas energy project
2. LFG Energy Benefits Calculator
    - Estimates methane reductions, avoided CO_2 emissions, and energy benefits (e.g., homes powered) from LFG projects
3. RNG Flow Rate Estimation Tool
    - Helps estimate adjusted flow rates and heat content of LFG for renewable natural gas (RNG) projects, especially when nitrogen specifications must be met.
4. Interactive Conversion Tool
    - Converts units (e.g., SCFM to MMSCFD) and estimates LFG energy potential from waste-in-place data
5. LandGEM (Landfill Gas Emissions Model)
    - Estimates total LFG and methane generation, as well as emissions of CO_2, NMOCs, and other pollutants. Useful for regulatory compliance and project planning
6. LMOP Database and Locator
    - A searchable database of candidate landfills and potential end users of LFG. Helps match landfills with nearby facilities that could use the gas

7. Project Development Handbook
    - Offers guidance on the technical, economic, and regulatory aspects of LFG energy project development
8. National Map of LFG Energy Projects
    - An interactive map showing operational LFG energy projects across the U.S., including electricity generation, direct use, and RNG applications

Limitations to Consider:

- Not a Regulatory Tool
    - LMOP is a voluntary program, and its tools are not designed for regulatory compliance or permitting. Users must consult local, state, and federal regulations separately.
- Simplified Economic Modeling
    - Tools like LFGcost-Web provide preliminary financial estimates but may not capture:
        - Site-specific capital and O&M costs
        - Local utility rates or incentives
        - Financing structures or tax implications
- Limited Technical Customization
    - Tools such as the LFG Energy Benefits Calculator and LandGEM use default assumptions for gas generation, energy conversion, and emissions, which may not reflect actual site conditions.
- No Real-Time Data Integration
    - LMOP tools do not integrate with real-time monitoring systems or GIS-based landfill operations, limiting their use for ongoing project management.
- Static Emission Factors
    - Emission reductions are based on standardized factors, not dynamic modeling of methane capture efficiency or combustion technology performance.
- Limited Scope for RNG Projects
    - While LMOP has expanded to include renewable natural gas (RNG), tools like the RNG Flow Rate Estimation Tool are still evolving and may not fully support complex RNG project modeling.
- LandGEM Model Limitations
    - LandGEM, used for estimating LFG generation, assumes first-order decay and may not accurately model:
        - Seasonal variations
        - Site-specific waste composition
        - Operational practices like leachate recirculation
- No Lifecycle or Co-Benefit Analysis

- LMOP tools focus on methane and CO_2 reductions, but do not account for:
  - Lifecycle emissions
  - Air quality co-benefits
  - Public health or economic development impacts

1.1.12. The EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT)

The EPA Facility Level Information on Greenhouse Gases Tool (FLIGHT)[16] is an interactive, web-based platform that allows users to explore greenhouse gas (GHG) emissions data reported under the Greenhouse Gas Reporting Program (GHGRP). It is designed to enhance transparency and public access to emissions data from large facilities across the United States.

The FLIGHT tool can be used for:

- Policy and Planning: Support climate action planning and emissions reduction strategies.
- Public Transparency: Enable communities to understand local industrial emissions.
- Academic Research: Provide data for environmental studies and modeling.
- Corporate Benchmarking: Compare emissions performance across facilities or sectors.

Key Features of the FLIGHT Tool:

- Facility-Level Emissions Data
  - View GHG emissions from over 8,000 facilities in sectors like power generation, manufacturing, oil and gas, and waste.
  - Data includes CO_2, CH_4, N_2O, and fluorinated gases.
- Interactive Mapping and Visualization
  - Search by location, facility name, industry type, or NAICS code.
  - Visualize emissions data using maps, pie charts, bar graphs, and trend lines.
- Custom Filtering
  - Filter by:
    - Data year
    - GHG type
    - Emission range
    - Fuel type
    - Facility or parent company
- Downloadable Reports

[16] https://www.epa.gov/ghgreporting

    - Export data tables, charts, and facility lists for further analysis or reporting.
- Trend Analysis
    - View emissions trends over multiple years for individual facilities or sectors.
- Cross-Referencing
    - Crosswalks available to link GHGRP data with other federal datasets (e.g., EIA, SO_2/NO_x programs).

Limitations to Consider:

- Covers Only Large Emitters
    - FLIGHT includes data only from facilities that emit 25,000 metric tons or more of CO_2-equivalent GHGs per year.
    - This excludes many small- and medium-sized emitters, meaning the tool does not represent total U.S. emissions
- No Scope 2 or Scope 3 Emissions
    - The tool focuses on direct (Scope 1) emissions only.
    - It does not include indirect emissions from purchased electricity (Scope 2) or supply chain and product use (Scope 3).
- Limited Sector Coverage
    - While it covers major sectors like power plants, refineries, and manufacturing, some sectors (e.g., agriculture, small businesses, and residential) are not included.
- Annual Reporting Only
    - FLIGHT provides annual emissions data, with no sub-annual (e.g., monthly or quarterly) resolution.
    - This limits its usefulness for real-time monitoring or seasonal analysis.
- No Emissions Forecasting
    - The tool is retrospective only—it does not model or forecast future emissions trends or impacts of mitigation strategies.
- No Lifecycle or Co-Benefit Analysis
    - FLIGHT does not include lifecycle emissions, health impacts, or economic co-benefits of emissions reductions.
- Data Lag
    - There is typically a 1–2 year delay between the reporting year and data availability in FLIGHT.
    - Start Year of Data Availability: 2010
    - Most Recent Year of Data Availability: Typically, data is available up to two years prior to the current year due to the reporting and verification process. As of 2025, the most recent data is likely from 2023.
- No Custom Scenario Modeling
    - Users cannot simulate “what-if” scenarios or policy impacts within the tool.