HAMPTON ROADS PDC

Comprehensive Climate Action Plan

November 2025

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Acronyms

AREC	Agriculture Research and Extension Center
BAU	Business-as-usual
BMP	Best Management Practice
C&I	Commercial and industrial
CAC	Community Advisory Committee
CAP	Criteria air pollutants
CBF	Chesapeake Bay Foundation
CBO	Community based organizations
CCAP	Comprehensive Climate Action Plan
CMAQ	Congestion Mitigation and Air Quality
CNU	Christopher Newport University
COBRA	Co-Benefits Risk Assessment
CPRG	Climate Pollution Reduction Grant
CSA	Community-supported agriculture
CTE	Career and Technical Education
CVOW	Coastal Virginia Offshore Wind
DCR	Department of Conservation and Recreation
DEQ	Department of Environmental Quality
DERA	Diesel Emissions Reduction Act
DHCD	Department of Housing and Community Development
DoD	Department of Defense
DOE	Department of Energy
DOF	Department of Forestry
DRPT	Department of Rail and Public Transportation
EPA	Environmental Protection Agency
ESPC	Energy Savings Performance Contracting
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
GO	Green Operator
GRIP	Grid Resilience and Innovation Partnerships
HAP	Hazardous air pollutants
HEAR	Home Electrification and Appliance Rebates
HRPDC	Hampton Roads Planning District Commission
HRSD	Hampton Roads Sanitation District
HRT	Hampton Roads Transit
HRTPO	Hampton Roads Transportation Planning Organization
HVAC	Heating, ventilation, and air conditioning
IEDO	Industrial Efficiency and Decarbonization Office
IGSA	Intergovernmental support agreements
LEAP	Local Energy Alliance Program
LEED	Leadership in Energy and Environmental Design
LIDAC	Low-Income and Disadvantaged Community
LRTP	Long Range Transportation Plan
MARAD	Maritime Administration
MHHW	Mean higher high water
MPO	Metropolitan Planning Organization
MRF	Material recovery facility
MSA	Metropolitan statistical area
MT	Metric tons
MWEE	Meaningful Watershed Education Experiences
NC	North Carolina
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCUC	North Carolina Utilities Commission
NEVI	National Electric Vehicle Infrastructure
NGO	Non-governmental organizations
NIT	Norfolk International Terminals
NNMT	Newport News Marine Terminal
NOAA	National Oceanic and Atmospheric Administration
NVRC	Northern Virginia Regional Commission
ODS	Ozone-depleting substances
PACE	Property Assessed Clean Energy

PCAP	Priority Climate Action Plan
PDR	Purchase of Development Rights
PJM	Pennsylvania, New Jersey, and Maryland
PMT	Portsmouth Marine Terminal
PPA	Power purchase agreements
PV	Photovoltaic
REAP	Rural Energy for America Program
REC	Renewable energy certificates
RMT	Richmond Marine Terminal
RNG	Renewable natural gas
RPO	Regional Planning Organizations
RTAP	Regional Transit Advisory Panel
SCC	State Corporation Commission
SOP	System Optimization Plan
SPR	Soil Profile Rebuilding
SPSA	Southeastern Public Service Authority
SRF	State Revolving Fund
STBG	Surface Transportation Block Grant
STEM	Science, technology, engineering, and math
SWCD	Soil, Water, and Conservation Districts
TMDL	Total Maximum Daily Load
TPO	Transportation planning organization
USBC	Uniform Statewide Building Code
USDA	United States Department of Agriculture
USDOT	U.S. Department of Transportation
VCEA	Virginia Clean Economy Act
VDOT	Virginia Department of Transportation
VEEP	Virginia Environmental Excellence Program
VEPGA	Virginia Energy Purchasing Governmental Association
VIG	Viginia International Gateway
VMT	Vehicle miles traveled
VPA	Virginia Port Authority
VTA	Virginia Technical Academy
WIP	Watershed Implementation Plan
WWTP	Waste water treatment plan
ZEV	Zero emissions vehicle

Executive Summary

The Hampton Roads Planning District Commission (HRPDC) developed the region's first **Comprehensive Climate Action Plan (CCAP)** through a two-year collaboration with local governments, state agencies, businesses, non-profits, and residents across the Virginia Beach–Norfolk–Newport News, VA-NC Metropolitan Statistical Area. Funded through a planning grant from the US Environmental Protection Agency (EPA), the CCAP provides a regional roadmap to reduce greenhouse gas (GHG) emissions, improve air quality, and grow the region's clean energy workforce across six sectors. Building on existing successful initiatives in the region and opportunities voiced by community members, this plan identifies 14 practical measures and associated actions to guide progress toward net zero emissions by 2050. The plan complements existing local and state initiatives, aligning with comprehensive, transportation, and sustainability plans rather than replacing them. Community priorities, heard throughout this plan's engagement activities, are seen in the measures with the overarching themes of increased investment in transit and safe and continuous bike and pedestrian infrastructure, protection and enhancement of natural systems, acceleration of the clean energy transition, and demand for effective regional collaboration. Additionally, throughout this plan there are existing project highlight boxes, showcasing local successes and programs that provide a foundation of experience and knowledge that can be drawn upon to support implementation of this plan.

Over the past two years, HRPDC and partners have:

- **Completed the region's first GHG emissions inventory** (2022 baseline: 22.6 million metric tons gross / 18.8 million metric tons net carbon dioxide equivalent (CO_2e)).
- **Engaged over 1,500 residents and stakeholders** through 2 webinars, 3 public surveys, 12 community events, 6 in-depth interviews, and the interactive "Climate Cash" participatory budgeting activity.
- **Developed 14 GHG reduction measures** across six major sectors: energy, buildings, transportation, waste, agriculture and natural lands, and industry.
- **Modeled a business-as-usual and a net zero pathway**, showing that the region could reduce emissions by roughly **90% by 2050** compared to 2022 levels.

Sunset over the Hampton Roads Bridge-Tunnel. Source: HRPDC

This report brings together data, community input, and policy guidance to shape a coordinated path forward. It includes:

- **Sector Snapshots** illustrating where emissions come from and what actions are possible.
- **Community Voices** summarizing what residents and stakeholders identified as top regional priorities.
- **Measures & Actions** outlining the practical steps localities and partners can take to reduce emissions and strengthen resilience.
- A **Benefits Analysis** detailing how climate action improves public health, equity, and economic outcomes.
- A **Workforce Assessment** highlighting local workforce surpluses, shortages, and opportunities for clean energy career growth.

Engagement

Development of the CCAP was grounded in a robust regional engagement process throughout 2024–2025 that reached over 1,500 participants through webinars, surveys, community events, interviews, and advisory briefings. Engagement efforts emphasized inclusion of the general public, technical experts, and socially vulnerable populations to ensure that the plan reflects regional priorities. Participants highlighted five key priorities: improved public transit and active mobility options; protection and expansion of natural systems; accelerated adoption of clean energy; enhanced waste management and recycling; and equitable access to sustainable solutions. Lessons learned underscored the success of innovative tools like the "Climate Cash" participatory budgeting activity, the importance of accessible digital platforms, and the challenge of engaging a geographically large and diverse region.

Measures

Table 1 below shows the list of measures identified in this plan. These measures address both direct emissions reductions and carbon sequestration opportunities, collectively capable of reducing net GHG emissions by roughly 90% from 2022 levels by 2050. Development of these measures was guided by the CCAP Steering Committee through an iterative, data-driven, and participatory process, building from the 2024 Priority Climate Action Plan and regional sustainability initiatives. The measures and their supporting actions were refined based on stakeholder feedback to ensure feasibility and alignment with local priorities. The resulting "Pathway to Net Zero" scenario illustrates how a combination of strategies, such as large-scale wetland and forest restoration, widespread adoption of zero-emission vehicles, building electrification and efficiency improvements, and increased use of clean and low-carbon fuels, can drive the region's long-term emissions reductions.

The 14 measures span six sectors:

- **Energy Supply:** Cleaner sources of energy can be used to power our homes, businesses, and transportation.
- **Buildings:** Buildings can run more efficiently and be more resilient to the impacts of climate change, helping to keep the lights on while consuming less power.
- **Transportation & Mobility:** Switching to electric and fuel-efficient vehicles and equipment, increased use of public transportation, and options like walking and biking can have major community and health benefits.
- **Solid Waste and Wastewater:** Better recycling practices and expanded composting activities can help reduce emissions from our landfills, and process efficiency improvements can help reduce emissions from wastewater treatment plants.

Infiltration area at College Park Elementary School in Virginia Beach. Source: HRPDC

- **Agriculture and Natural Lands:** Conserving, restoring, and managing lands to preserve and enhance their benefits – such as wetland and living shoreline restoration and increased tree canopy – can support GHG reductions and increase community protection from storms and flooding.
- **Industry:** Finding collaborative solutions for clean energy use and efficiency improvements along our industrial corridors can help reduce pollution.

Table 1: GHG Reduction Measures

#	Sector	Measure
NWL1	Agriculture and Natural Lands	Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands
NWL2	Agriculture and Natural Lands	Support local food production, urban agriculture, and farm-to-school initiatives
NWL3	Agriculture and Natural Lands	Increase soil conservation practices on urban and agricultural lands
T1	Transportation	Increase the adoption of low and zero-emission vehicles by developing education, outreach, and planning materials to localities for purchasing and maintaining zero-emission vehicles and develop a fueling infrastructure deployment strategy
T2	Transportation	Reduce vehicle miles traveled and support alternative modes of transportation through bike/pedestrian infrastructure investments
B1	Buildings	Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for local government and school buildings
B2	Buildings	Reduce energy consumption and increase building efficiency through programs to support, incentivize, and install weatherization and electrification measures in residential buildings
B3	Buildings	For commercial and industrial buildings, increase energy efficiency through financial incentives and educational outreach programs and strongly encourage the design, building, and operation of buildings above current required code
E1	Energy Supply	Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub
E2	Energy Supply	Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency
I1	Industry	Support emissions reductions from industrial processes
I2	Industry	Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes
W1	Waste and Wastewater	Decrease the amount of waste sent to landfills
W2	Waste and Wastewater	Support efficiency upgrades at wastewater treatment plants

Hampton Roads transit bus. Source: HRPDC

Successful implementation of these measures will require collaboration across all levels of government and active engagement from the private sector and community partners. While local governments in Virginia and North Carolina hold clear authority in areas such as land use, zoning, public infrastructure, and municipal operations, many measures – particularly those related to building codes, energy generation, and industrial emissions – fall under state or federal jurisdiction. Localities play a critical enabling role by shaping policies, streamlining permitting, leading by example, and fostering partnerships that align with state and federal frameworks. Equally important, implementation depends on access to sustained and diversified funding. Federal and state programs provide the largest sources of support supplemented by utility programs and emerging financing tools such as green banks. However, many federally funded programs remain subject to annual appropriations and policy changes, underscoring the need for adaptable, blended funding strategies that leverage public, private, and philanthropic resources. By collaborating on implementation and combining funding streams, communities across the region can move from planning to implementation and achieve measurable progress toward a resilient future.

Benefits Analysis

Implementing these measures will bring broad public health, environmental, and economic benefits to the region. Reducing harmful air pollutants will improve indoor and outdoor air quality, lower risks of respiratory and cardiovascular illness, and enhance overall community wellbeing. Expanding tree canopy and natural lands will help manage stormwater, reduce heat, and protect water quality, while clean energy and efficient infrastructure will improve grid reliability and climate resilience. Collectively, these outcomes will reduce costs related to pollution, healthcare, and extreme weather events—supporting a healthier, more sustainable, and economically secure Hampton Roads.

Workforce Assessment

The Workforce Assessment examines the Hampton Roads region's capacity to support implementation of the CCAP and identifies strategies to ensure a skilled, resilient, and inclusive labor force for the clean energy transition. The CCAP is expected to directly impact approximately 88,000 jobs across 50 occupations, or nearly 10% of the region's total employment, spanning construction, energy, transportation, waste management, and natural lands. While the current labor market shows only minor shortages or surpluses, workforce needs will grow as implementation advances—particularly for electricians; heating, ventilation, and air conditioning (HVAC) technicians; and construction workers supporting clean energy, efficiency, and infrastructure projects.

Addressing these needs requires a coordinated regional approach that goes beyond technical training to confront broader structural and economic barriers. Even when workers have the right skills, factors such as rigid job requirements, high housing and childcare costs, and limited transportation access can restrict participation and retention. Collaboration among employers, educational institutions, workforce boards, and public agencies will be essential to build an ecosystem that connects training with opportunity—through targeted upskilling and early-career technical pathways. By aligning regional investment and policy, Hampton Roads can build a workforce equipped to meet the demands of CCAP implementation while promoting equitable access to quality jobs and long-term economic resilience.

Moving Forward

Hampton Roads residents riding public transit. Source: HRPDC

Implementation success will depend on sustained collaboration and shared responsibility among local governments, businesses, utilities, non-profits, and residents. Many CCAP-aligned initiatives are already underway, including fleet electrification, EV charging network expansion, clean energy programs, regional transit improvements such as the 757 Express, and development of a connected regional trail system. While some actions can be advanced in the near term, others will evolve over the next decade or more as resources and capacity grow. It is important to understand that any plan is a long-term strategy developed with available information at a particular point in time. While we have made every effort to develop an effective plan and strategy, we are committed to evaluating the effectiveness of the recommendations and making adjustments over time for the benefit of our region. In the near term, HRPDC will continue to monitor progress, adapt strategies, and report on outcomes in the 2027 Status Report.

Introduction

Purpose and Scope

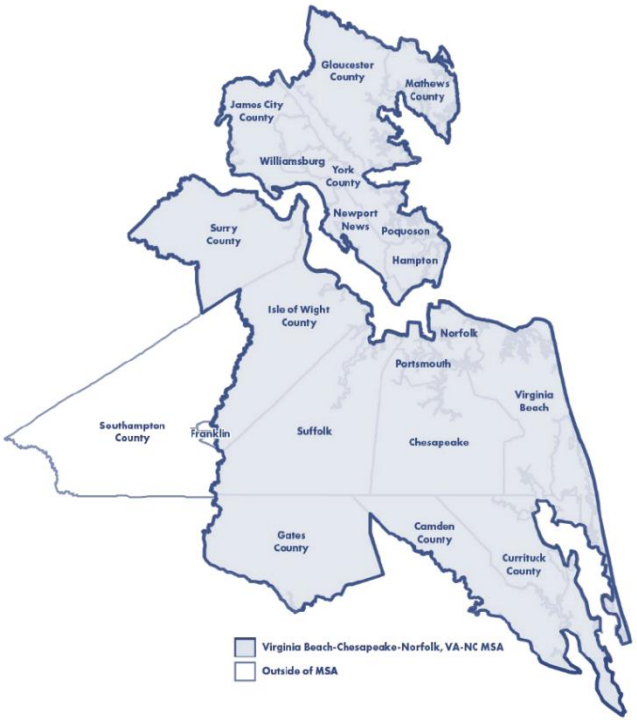
For over two years, HRPDC staff have been working with locality staff, community members, state agencies, consultants, private industry, non-profit organizations, and residents across the Virginia Beach-Norfolk-Newport News, VA-NC Metropolitan Statistical Area (MSA) region to develop the region's first Comprehensive Climate Action Plan (CCAP) report. The plan provides a roadmap to benefit our region by advancing an overall plan for localities, agencies, industry, and communities to work together to reduce emissions, improve local air quality, support clean energy workforce development, and identify methods to ensure a just and equitable energy transition throughout the region. This plan reflects significant input from the community; HRPDC held 2 webinars, released 3 surveys, tabled 12 events in six different localities, created an online climate investment activity, and conducted 6 long form interviews. The plan has three main goals:

- Tackle damaging climate pollution while supporting the creation of good jobs and lowering energy costs for families.
- Accelerate work to address environmental injustice and empower community-driven solutions in overburdened neighborhoods.
- Deliver cleaner air by reducing harmful air pollution in places where people live, work, play, and go to school.

This plan covers the full Virgina Beach-Chesapeake-Norfolk, VA-NC MSA and includes data on GHG and other air quality pollutants in the region; identifies key strategies, or measures, to reduce emissions in the region; provides a potential pathway to net zero GHG emissions by 2050; and includes an assessment of potential benefits and workforce considerations for implementing the identified measures. This vision will be co-created; localities can use this plan to guide future work and integrate measures and actions that are relevant for their local context.

The CCAP complements – rather than replaces – other local, regional, and state planning efforts. It is intended to sit alongside comprehensive plans, transportation plans, equity and sustainability strategies, and economic development initiatives, aligning across multiple policy areas without superseding or duplicating them. The plan includes a total of 14 measures to reduce emissions, improve air quality and improve local resilience across six sectors:

Figure 1: HRPDC-covered jurisdictions and the MSA boundary



- **Energy Supply:** Cleaner sources of energy can be used to power our homes, businesses, and transportation.
- **Buildings:** Buildings can run more efficiently and be more resilient to the impacts of climate change, helping to keep the lights on while consuming less power.
- **Transportation & Mobility:** Switching to electric and fuel-efficient vehicles and equipment, increased use of public transportation, and options like walking and biking can have major community and health benefits.
- **Solid Waste and Wastewater:** Better recycling practices and expanded composting activities can help reduce emissions from our landfills, and process efficiency improvements can help reduce emissions from wastewater treatment plants.

- **Agriculture and Natural Lands:** Conserving, restoring, and managing lands to preserve and enhance their benefits – such as wetland and living shoreline restoration and increased tree canopy – can support GHG reductions and increase community protection from storms and flooding.
- **Industry:** Finding collaborative solutions for clean energy use and efficiency improvements along our industrial corridors can help reduce pollution.

Plan Development

This plan is the culmination of two years of work and stakeholder and community engagement. After kicking off in late 2023, HRPDC first released a Priority Climate Action Plan (PCAP) in March 2024 that included high level measures and actions and a simplified GHG inventory. The PCAP was a pre-requisite for the region to apply for EPA's implementation grants, which were due April 2024. While HRPDC did not receive any implementation funding, a multi-state coalition including Virginia was awarded a grant focused on projects that promote coastal resilience and sustainable forestry management practices.

After submission of the PCAP, HRPDC began development of this CCAP, which includes additional sectors and an expanded list of GHG reduction measures. Identification of measures and implementation actions for each sector were informed by data from the GHG emissions inventory and engagement of community members and stakeholder organizations.

Engagement Summary

The CCAP was informed by a multi-channel public and stakeholder engagement process conducted throughout 2024 and 2025. The primary objective was to solicit meaningful feedback from communities across the 20-locality MSA to ensure the final plan reflects regional priorities. The engagement aimed to reach the general public, as well as key technical, civic, and vulnerable population audiences. Feedback from these activities was used to refine the CCAP's measures and actions. Community engagement is expected to continue as HRPDC prepares the Status Report, which is due in 2027. A summary of the engagement process is included here with an accompanying detailed Engagement Report in Appendix D.

Engagement by the Numbers

The comprehensive outreach strategy employed a wide range of methods to maximize public input:

- **2 Public Webinars** were held in January and June 2025, reaching a combined total of approximately 125 attendees.
- **3 Public Surveys** were conducted: two general public surveys garnered a combined **497 responses** and a specialized vehicle miles traveled (VMT) survey collected input from **40 transportation professionals**.
- **11 In-Person Community Events** allowed for direct outreach to over **900 residents** at festivals, transit centers, and community fairs across the region.
- **6 Long-Form Interviews** were conducted with leaders from community-based organizations to gather in-depth, qualitative feedback.
- **5+ Committee Briefings** ensured technical and civic advisory bodies, including the Community Advisory Committee (CAC), Regional Transit Advisory Panel (RTAP), and the CCAP Steering Committee, provided guidance.
- **"Climate Cash" Participatory Budgeting** was a hands-on activity used at multiple events and later digitized, allowing residents to "invest" in their preferred climate actions.

What We Heard

Across all engagement methods – from surveys to in-person conversations – several clear and consistent priorities for climate action in Hampton Roads emerged.

1. **Need for Transportation and Land Use Reform:** The most dominant theme was a decisive demand to move away from the region's car dependency. Residents and technical experts consistently called for expanded and more reliable public transit, alongside significant investments in safe, connected infrastructure for walking and biking, such as protected bike lanes and continuous sidewalks. Many participants expressed that they are reliant on public transportation but feel the current system is unable to meet their needs.
2. **Protection and Expansion of Natural Systems:** The community voiced powerful support for preserving and expanding green spaces. In surveys and at community events, protecting the urban tree canopy, restoring wetlands, and conserving natural habitats from development were cited as critical priorities. In Survey II, "Expand urban tree canopy and green space" was the single highest-ranked action item among all proposed measures.
3. **Accelerated Transition to Clean Energy:** There was strong public support for a transition to renewable energy sources. Key actions favored by the community included expanding the electric vehicle (EV) charging network and enhancing solar energy programs for both residential and commercial buildings.
4. **Improved Waste Management and Recycling:** Residents expressed a clear desire for more accessible and effective recycling programs and the diversion of organic materials from landfills. Frustration was noted in localities where curbside recycling had been discontinued.
5. **Consideration of Socially Vulnerable Persons:** Among respondents, there was a common desire to ensure that any plan developed prioritizes the needs of socially vulnerable persons and considers the numerous barriers that prevent them from accessing sustainable solutions, such as cost, access, and education.

Our Planet, Our Power Event. Connecting with community members. Source: HRPDC

Cap2Cap event. Interacting with community members. Source: HRPDC

Key Takeaways and Lessons Learned

The engagement process yielded valuable insights for future regional outreach efforts:

- **Successful Innovation:** The **"Climate Cash"** participatory budgeting activity proved to be a highly effective and popular tool. It successfully gamified complex budget topics, making them more accessible and engaging for the public and providing clear data on community priorities.
- **Prioritize User-Friendly Technology:** Technical difficulties with Survey II's ranking question caused user frustration and highlighted the need to prioritize simple, reliable, and mobile-friendly platforms for digital engagement.
- **Challenges of a Large, Diverse Region:** The vast size of the Hampton Roads MSA made it difficult to achieve uniform engagement across all 20 localities. Future efforts will require even more targeted outreach to ensure equitable participation, particularly in the western and northern areas of the region.

How To Read This Report: Key Terms and Definitions

What are greenhouse gases emissions?

Invisible gases are released into the air when we burn fossil fuels through activities such as driving cars, heating buildings, producing electricity, farming, and industrial processes. These gases trap heat in the atmosphere, causing climate change and an increase in the average global temperature. There are six main GHGs:

1. Carbon dioxide (CO_2) – from burning fossil fuels like coal, oil, and gas
2. Methane (CH_4) – from landfills, livestock, and natural gas systems
3. Nitrous oxide (N_2O) – from fertilizers, farming, and some industrial processes
4. Hydrofluorocarbons (HFCs) – emissions come from a range of sources where HFCs are used primarily as substitutes for ozone-depleting substances (ODS) in refrigeration or air conditioning or for specific industrial applications
5. Perfluorocarbons (PFCs) – from aluminum production and electronics manufacturing
6. Sulfur hexafluoride (SF_6) – used as an insulating gas in electrical equipment

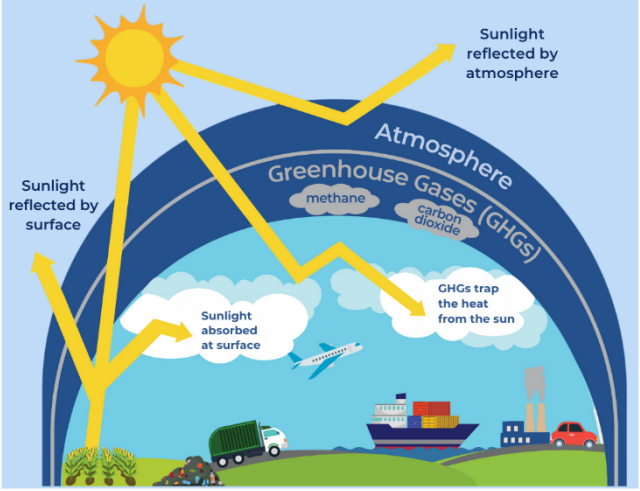
What are Greenhouse Gas (GHG) Emissions?

GHGs trap heat from the sun around the planet, like in a greenhouse. While GHGs naturally occur in our atmosphere, increased GHGs due to human activities can raise temperatures and increase climate variability.

Here are some everyday activities that increase GHGs:

- Using fossil fuels for our cars, heating, electricity, cooking, and more
- Cutting down trees
- Industrial processes in factories
- Managing and disposing of waste

The Climate Action Plan identifies strategies and actions to reduce GHG emissions and protect our community from negative impacts of climate change.



What does "CO_2 Equivalent" mean?

Not all greenhouse gases are equal — some trap much more heat than others. To make it easier to compare and add up the impact of different gases, scientists use something called carbon dioxide equivalent, or **CO_2e**. CO_2e is a common unit that expresses the warming impact of any greenhouse gas in terms of how much carbon dioxide (CO_2) would cause the same amount of warming over 100 years. This standard way of measuring helps us understand the total impact of all emissions, using one consistent unit — no matter which gas is being emitted.

For example, 1 ton of methane (CH_4) warms the planet 28 times more than 1 ton of CO_2 over 100 years, so 1 ton of methane is equivalent to 28 tons CO_2e.

What is a Metric Ton?

- GHG emissions are usually measured in metric tons, which is the standard unit used around the world.
- 1 metric ton = 1,000 kilograms
- That's about 2,205 pounds or 1.1. US tons (also known as short tons)

What is carbon sequestration?

Sequestration is the process of capturing carbon dioxide from the atmosphere (or from emission sources) and storing it so it doesn't contribute to climate change. The goal of increasing sequestration is to reduce the amount of CO_2 in the atmosphere, helping slow down climate change. There are two main types:

- **Natural sequestration**: Forests and soil naturally absorb CO_2. For example, trees take in CO_2 during photosynthesis.
- **Technological sequestration**: Methods that capture CO_2 from power plants, industrial facilities, or directly from the air and store it underground or use it in products.

Gross vs. Net GHG Emissions

Gross GHG emissions are the total emissions released into the atmosphere — including from activities like burning fossil fuels, agriculture, or industrial processes. **Net** GHG emissions take that gross number and subtract any CO_2 that is removed (or "sequestered") from the atmosphere through natural or technological means.

When reporting emissions, both gross and net figures are important. Gross emissions show the scale of total GHGs released into the atmosphere, while net emissions show how much is being sequestered. The net amount of GHGs in the atmosphere is an important metric for assessing rising global temperatures and climate change impacts. Many climate targets, including this plan's goal, focus on net emissions (e.g., achieve net zero emissions by 2050), aiming for a balance between emissions produced and emissions removed.

What are co-pollutants – and why do they matter?

When we reduce greenhouse gas (GHG) emissions — especially from burning fossil fuels — we also reduce other harmful air pollutants that affect local air quality and health. These are called co-pollutants. When we take climate action (like switching to clean energy or reducing car traffic), we also reduce emissions from co-pollutants. This means cleaner air, healthier communities, fewer hospital visits and missed days of work and school, and greater benefits to overburdened communities, which often face the highest pollution levels. There are two main categories of co-pollutants:

- **Hazardous Air Pollutants** (HAPs): Also known as air toxics, these pollutants are known or suspected to cause cancer, birth defects, or serious health problems. Examples include Volatile Organic Compounds like benzene, formaldehyde, and mercury.
- **Criteria Air Pollutants** (CAPs): These are six common air pollutants regulated by EPA because they harm human health and the environment:
  - particulate matter ($PM_{2.5}$ and PM_{10}) – tiny particles that can enter the lungs and bloodstream
  - ground-level ozone (O_3) – formed when other pollutants react in sunlight and can worsen asthma
  - nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) – cause respiratory issues and smog
  - carbon monoxide (CO) – reduces oxygen delivery in the body
  - lead (Pb) – toxic to the brain and nervous system, especially in children

Key Climate Change Impacts

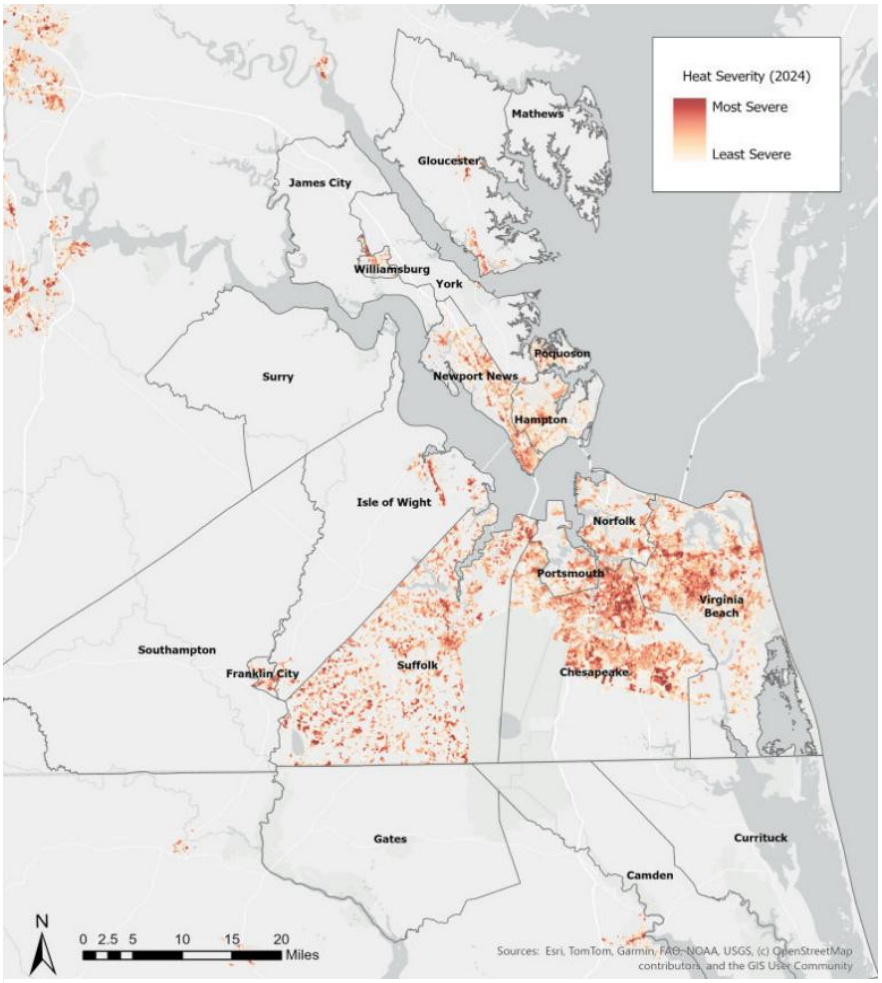
The climate risks most prevalent in the U.S. include extreme weather events (hurricanes, extreme rainfall, etc.), extreme heat and urban heat island effects, flooding, sea level rise, drought, and wildfires. Low income, disadvantaged communities often feel the most severe impacts of climate change because they lack the necessary resources to prepare for and respond to said impacts. The most prevalent climate risks and their potential impacts include:

Extreme Heat. Exposure to extreme heat can cause heat exhaustion, heat stroke, and can contribute to deaths from a range of cardiovascular diseases such as heart attacks and strokes. Between 2004 and 2018, an average of 702 people died annually of heat-related deaths in the United States (though this is likely underreported). Higher temperatures may lead to increased energy demand and higher energy costs, which can exacerbate heat-related health risks, especially for low-income communities.

Drought. Drought can contribute to water scarcity, causing major food insecurity and threatening farming livelihoods. Food insecurity leads to hikes in food prices and potentially civil unrest and mass migration.[1]

Extreme Weather Events (Hurricanes, Extreme Rainfall, Etc.). Extreme rain events will likely increase in frequency and intensity throughout the century. This will cause more intense flooding, harming primarily households without homeowners or renters' insurance or that cannot afford the necessary infrastructure repairs. Flooding can also impact human health by increasing mold production and exposure to waterborne diseases, particularly affecting those in poor living conditions.[2] Impacts from these storms will continue to be felt most significantly in densely populated areas along tidal waters.

Figure 2: MSA Urban Heat Island Severity



This map displays the "Heat Severity - USA 2024" layer developed by the Trust for Public Land and shows relative heat severity for every pixel in the Hampton roads MSA. Data is a 30-meter raster derived from Landsat 8 imagery ban 10 (ground-level thermal sensor) from the summer of 2024.

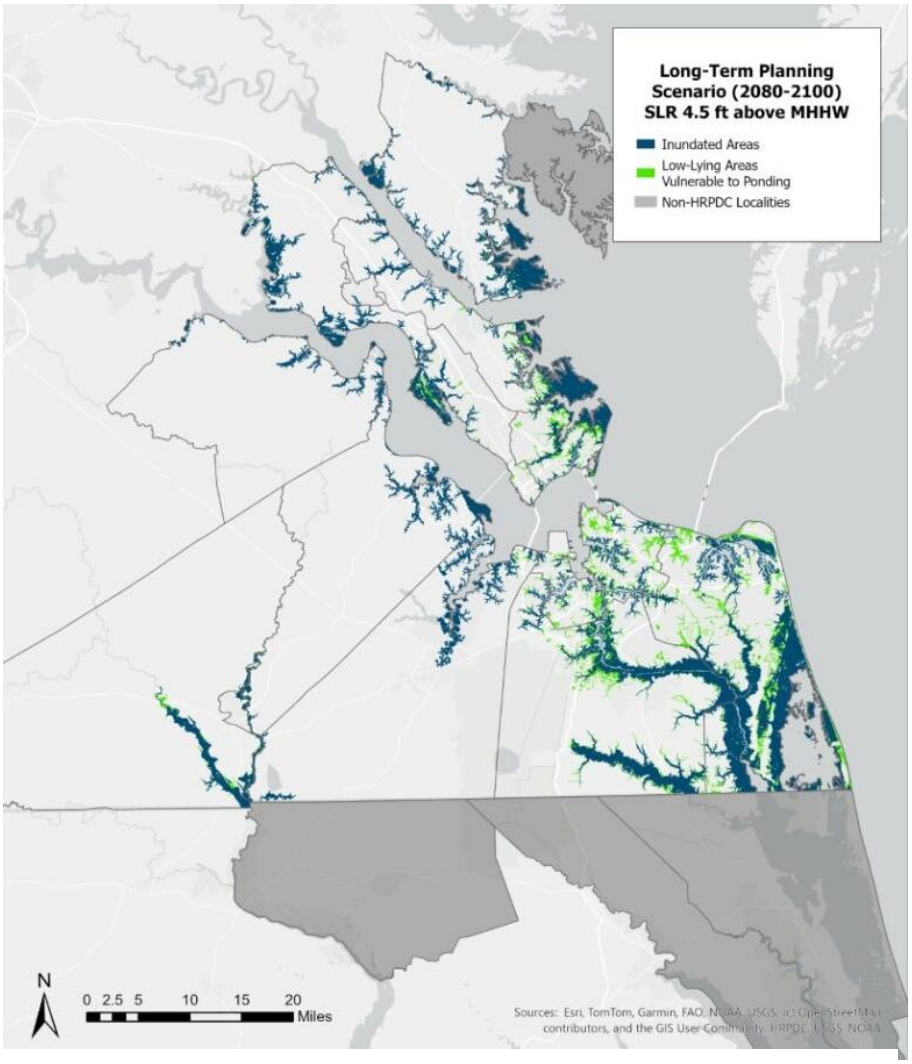
[1] U.S. Global Change Research Program. 2023: *Ch. 11. Agriculture, food systems, and rural communities. In: Fifth National Climate Assessment*. https://doi.org/10.7930/NCA5.2023.CH11

[2] EPA. 2021. *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003*. www.epa.gov/cira/social-vulnerability-report

Sea Level Rise. Sea level rise will cause severe flooding, damaging infrastructure. Additionally, saltwater intrusion from sea level rise can make drinking water unsafe for coastal communities, leading to dangerous impacts on health.[3] Sea level rise presents a major challenge for Hampton Roads, where projections indicate substantial land loss under a scenario of 3 feet of sea level rise by 2050.[4] At this level, approximately 116,000 acres of land would be permanently inundated, with wetlands accounting for nearly two-thirds of the area impacted (73,440 acres).[5] Figure 3 maps the impacts under a longer-term scenario, looking at impacts for 2080-2100 with sea level rise of 4.5 feet above mean higher high water (MHHW).

These losses are not incorporated into the current mitigation modeling framework, but they represent a critical factor for long-term land use and ecosystem stability in the region. These trends should be monitored, as the large-scale inundation of wetlands threatens natural carbon storage, habitat, and flood protection functions. Given the scale of the projected losses, adaptation and resilience strategies are needed to maintain the ecological viability of Hampton Roads under rising seas.

Figure 3: Sea Level Rise Planning Scenario for HRPDC Localities

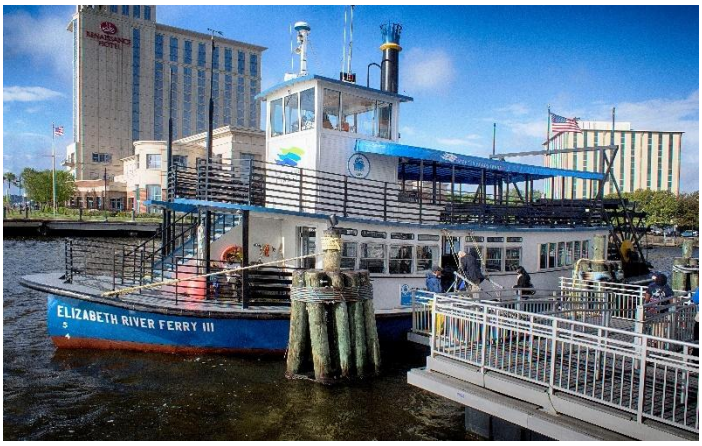


This map displays the Long-term planning (2080-2100) Sea Level Rise (SLR) planning scenario of 4.5 feet above Mean Higher High Water (MHHW). SLR Planning Scenarios were approved by HRPDC in October 2018. This SLR inundation layer was developed by HRPDC staff utilizing elevation and tidal surface data from USGS and NOAA. Note that this data layer does not display SLR for those localities outside of HRPDC boundaries due to the extent of the data.

[3] Shammi, M., Rahman, M., Bondad, S.E., Bodrud-Doza, M., 2019. *Impacts of Salinity Intrusion in Community Health: A Review of Experiences on Drinking Water Sodium from Coastal Areas of Bangladesh.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6473225/
[4] Hampton Roads Sea level rise planning scenario for 2050-2080 (3 feet of SLR above current mean higher high water).
[5] Chesapeake Conservancy 2018 LULC (2022) Edition.

Progress in the Region

Many regions and communities within the Hampton Roads MSA and key infrastructure assets are vulnerable to changing climatic conditions, particularly regarding flooding and sea level rise. Local and regional bodies have also developed climate action and related planning and funding initiatives. To date, HRPDC has developed a Coastal Resiliency Program that includes actions to address regional challenges related to flooding and sea level rise.



The Elizabeth River Ferry III provides public transportation between Norfolk and Portsmouth, VA. Source: HRPDC

Lying within Virginia, the Hampton Roads MSA is covered by state-level climate goals, such as those included in Senate Bill 94, establishing statewide GHG emissions reduction goals across Virginia's economy that reach net zero emissions by 2045, and the clean energy goals in the Virginia Clean Economy Act of 2020 (VCEA). In alignment with the VCEA, Virginia has also passed a number of recent bills to support equitable climate actions, including Clean Cars Act (House Bill 1965) and the Environmental Justice Act, all of which affect GHG emissions in the Hampton Roads MSA as they continue to come into effect. Several statewide efforts to plan for and fund increased climate resilience investments may also be applicable to the MSA region, including:

- Virginia Coastal Resilience Master Plan[6]
- Virginia Department of Conservation and Recreation: Guidance for Local Floodplain Ordinances[7]
- Virginia Strategy for Safeguarding Species of Greatest Conservation Need from the Effects of Climate Change[8]
- Funding mechanisms such as the Community Flood Preparedness Fund and the Resilient Virginia Revolving Fund[9]

With a few counties in North Carolina, the Hampton Roads MSA is also covered by Executive Order 80: North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy and the climate goals therein.

[6] Commonwealth of Virginia. 2021. *Virginia Coastal Resilience Master Plan Phase 1*. https://www.dcr.virginia.gov/crmp/plan.
[7] Virginia DCR. 2023. *Floodplain Management Regulations and Ordinances*. https://www.dcr.virginia.gov/dam-safety-and-floodplains/fpordnce.
[8] Virginia DWR. 2024. *Virginia's Strategy for Safeguarding Species of Greatest Conservation Need from the Effects of Climate Change.*. https://dwr.virginia.gov/wildlife/wildlife-action-plan/safeguarding-species-from-climate-change/.
[9] Virginia DCR. 2024. *Community Flood Preparedness Fund Grants and Loans*. https://www.dcr.virginia.gov/dam-safety-and-floodplains/dsfpm-cfpf.

GHG Emissions Inventory

Emissions inventories help to inform which regional areas and sectors should be prioritized during GHG reduction planning. The creation of an inventory is often the first step in an emissions reduction plan to ensure priority areas are identified and adequately responded to. This inventory was compiled for 2022 and assesses GHG sources and sinks across six key sectors: transportation, residential and commercial buildings, electric power use, industry, solid waste and wastewater, and agriculture and natural lands.

The region's first comprehensive emissions inventory will help inform climate mitigation planning, providing a benchmark to assess future progress.

Key Findings

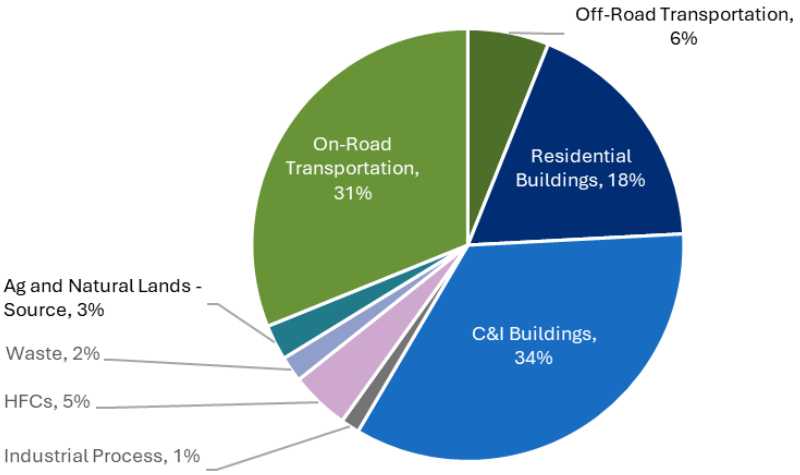
- Total gross emissions in 2022 were 22.6 $MMTCO_2e$, and total net emissions were 18.8 $MMTCO_2e$.
- The largest sources of emissions are electricity and natural gas use in residential, commercial and industrial (C&I) buildings, and light-duty vehicles.
- The largest categories of CO_2 sinks in the region from natural lands are forest (3.4 $MMTCO_2e$ sequestered) and urban trees (~ 0.4 $MMTCO_2e$ sequestered). The region's natural lands are key to help offset emission sources and also provide significant health and climate resilience benefits.

52% of gross emissions in the region are from the Buildings Sectors

2022 GHG Inventory Summary

The 2022 GHG inventory is a comprehensive assessment of all GHG emissions sources and sinks across the MSA. The inventory was developed using a consumption-based (Scope 1 and 2) approach, which accounts for the emissions associated with the electricity consumed within the region in addition to direct sources of emissions, such as the combustion of fossil fuels in vehicles or buildings. The inventory is also presented in terms of both gross and net emissions. Gross reporting reflects sources of emissions only, while net emissions consider carbon sinks as well, such as the carbon stored in forests and wetlands.

Figure 4: HRPDC MSA Gross Consumption-Based GHG Emissions Inventory by Sector, 2022



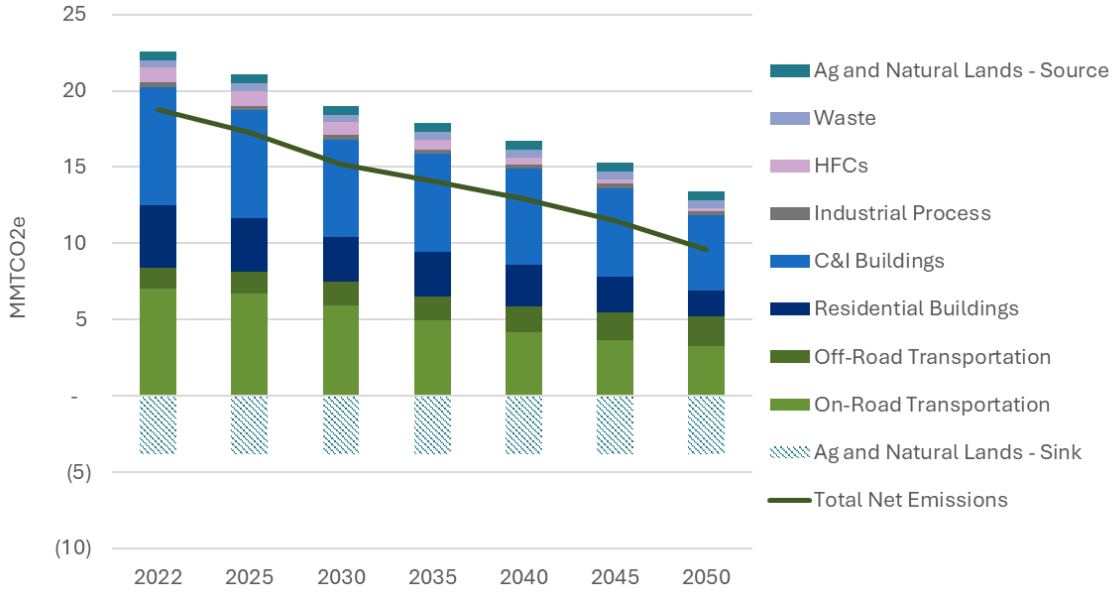
Total gross emissions in 2022 were 22.6 million metric tons CO_2e ($MMTCO_2e$). When accounting for the value of carbon stored in regional sinks, total emissions fall to 18.8 $MMTCO_2e$, with 3.8 $MMTCO_2e$ being stored in regional natural lands. Within the region, emissions vary largely across localities. Those with larger populations and commercial or industrial activity produce higher levels of emissions compared to rural areas. Less densely populated areas may also benefit from greater carbon sinks due to forest or grasslands. The highest emitting localities in the region are Virgina Beach, Norfolk, Chesapeake, and Newport News, all of which are hubs within the region for tourism, military and ship centered installations, and higher education. These localities also host over 60% of the region's population. Gates and Southampton Counties have the highest value of carbon sinks from natural lands.

Business As Usual Projections

A business-as-usual (BAU) GHG emission projection scenario was developed to understand how the region's emissions might look in the future without additional action. The BAU scenario reflects future emissions under current state and federal policies and includes historical trendlines and growth factors such as expected changes in population and employment. This scenario will serve as basis to compare emission reduction benefits from implementation GHG reduction measures.

Figure 5 shows the region's BAU GHG emission projections by sector, including both sources and sinks of CO_2 emissions from natural lands. **Compared to the 2022 inventory base year, the BAU projects that gross GHG emissions will decline 20% by 2035 and over 40% by 2050.** The largest projected reductions are from the transportation sector due to assumed increases in vehicle fuel efficiency and increased zero-emission vehicle adoption. The buildings sector also sees significant reductions due to cleaner electricity being used to power homes and businesses and improved equipment and appliance energy efficiency.

Figure 5: HRPDC MSA BAU GHG Projections by Sector



Key Findings

- By 2050, **transportation** sector emissions are projected to decline nearly 40% from 2022 levels driven by improved fuel efficiency and increase EV adoption.
- By 2050, commercial and residential **building** sector emissions are expected to decline nearly 45% from 2022 levels. These reductions are largely driven by state mandates in Virginia for a net zero emissions electric power sector by 2050, which lead to a lower carbon intensity for electricity consumed in buildings, and ongoing trends towards more energy efficient building appliances and equipment.
- Emissions from the **waste** sector are projected to rise as population growth increases overall waste generation.
- For the **agriculture and natural lands** sector, emissions from agriculture are expected to grow slightly based on historical trends tied to livestock populations. Carbon sequestered in natural lands is expected to remain constant in the BAU.
- **Industrial process** emissions are projected to stay relatively flat through 2050.
- **HFC** emissions decline over 80% by 2050 with implementation of the American Innovation and Manufacturing (AIM) Act, which directs EPA to phase down the production of HFCs in alignment with the Kigali Amendment to the Montreal Protocol, which was ratified in 2022.

Co-Pollutant Emissions Inventory

In addition to greenhouse gases, an emissions inventory for CAPs and HAPs was developed. Like a GHG inventory, tracking these co-pollutants over time provides an understanding of what pollutants are being released, how much, and key sources of them. There are two categories of air pollutants that affect human health and the environment:

- CAPs include ozone, particulate matter ($PM_{2.5}$, PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and may harm public health and the environment.
- HAPs, also known as air toxics, include over 180 chemicals such as benzene and mercury, which may cause cancer and other serious health impacts.

Health and Environmental Impacts

- CAPs and HAPs can cause breathing problems, asthma, heart disease, cancer and other health issues
- NO_2 / other NO_x in the atmosphere can result in acid rain which can harm ecosystems.

In addition, there are many types of pollutants that relate to both CAPs and HAPs, or that are considered a precursor pollutant that may react with other pollutants to form either a CAP or HAP and are thus important to track for air quality assessments.

- Volatile organic compounds (VOCs) are gases that come from things like fertilizer, paints, varnishes, cleaning supplies, gasoline, diesel, and building materials. When VOCs react with nitrogen oxides, they create ozone, a CAP. Some VOCs are HAPs, such as benzene or formaldehyde.
- Ammonia (NH_3) contributes to the formation of $PM_{2.5}$, a CAP, when it reacts with other pollutants like NO_x and SO_2.

Table 2 provides a summary of co-pollutant emissions in the region by sector and pollutant, with a focus on criteria pollutants. The data is compiled from EPA's 2022 Emissions Modeling Platform.

Table 2: HRPDC MSA Co-Pollutant Emissions (MT), 2022

Category	CO	NO_x	VOC	PM_{10}-PRI	PM_{25}-PRI	SO_2	NH_3	Total
Agriculture	12,958	1,651	82,254	5,440	1,693	65	5,204	109,265
Industrial Process	1,424	1,674	17,718	6,672	1,975	637	10	30,109
Mobile Transportation	128,551	18,352	11,054	1,336	791	322	852	161,257
Stationary (e.g., Buildings)	13,638	4,439	1,634	4,059	3,679	269	316	28,033
Waste	6,642	484	908	954	864	177	380	10,409
Other	452	11	114	4,974	939	1	-	6,489
TOTAL	**163,664**	**26,610**	**113,682**	**23,434**	**9,940**	**1,470**	**6,762**	**345,563**

GHG Emission Reduction Measures

Mitigation Measures

To identify the path to net zero, overarching **measures** were developed by sector to outline how stakeholders within the Hampton Roads MSA can mitigate or reduce GHG emissions. Within each sector there are several measures underpinned by **actions** that can be undertaken by localities, non-profits, and other entities. Not every measure will apply equally to every locality, organization, or partner, and the responsibility for achieving emissions reductions does not rest solely with local governments. While many partners have a role to play, local governments are uniquely positioned to lead by example and set the tone for broader community action. Together, these actions represent shared opportunities for residents, businesses, institutions, and agencies to contribute to a more sustainable, resilient, and low-carbon future. This section provides an overview of the measures, the GHG reduction potential through 2050 if they are fully implemented, the authority to implement them, and potential funding sources.

GHG Reduction Measures

Fourteen GHG reduction measures were identified for this CCAP, as presented in Table 3. These measures were developed through a collaborative and iterative process with the CCAP Steering Committee, regional government agencies and authorities, and stakeholders like community-based organizations, private sector actors, utilities, and community members. These strategies span buildings and clean energy, transportation, waste, and land use sectors. Discussed further in the *Pathway to Net Zero* section of this CCAP, these measures combined have the potential to achieve over 90% reduction in net emissions by 2050 compared to the 2022 inventory base year.

The identified measures are organized and numbered by the following sectors:

- **Agriculture and Natural Lands.** Conserving, restoring, and managing lands to preserve and enhance their benefits – such as wetland and living shoreline restoration and increased tree canopy – can support GHG reductions and increase community protection from storms and flooding.
- **Transportation.** Switching to electric and fuel-efficient vehicles and equipment, increased use of public transportation, and options like walking and biking can have major community and health benefits.
- **Buildings and Energy Use.** Buildings can run more efficiently and be more resilient to the impacts of climate change, helping to keep the lights on while consuming less power.
- **Energy Supply.** Cleaner sources of energy can be used to power our homes, businesses, and transportation.
- **Industry.** Finding collaborative solutions for clean energy use and efficiency improvements along our industrial corridors can help reduce pollution.
- **Waste and Wastewater.** Better recycling practices and expanded composting activities can help reduce emissions from our landfills, and process efficiency improvements can help reduce emissions from wastewater treatment plants.

Table 3: GHG Reduction Measures

#	Sector	Measure
NWL1	Agriculture and Natural Lands	Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands
NWL2	Agriculture and Natural Lands	Support local food production, urban agriculture, and farm-to-school initiatives

#	Sector	Measure
NWL3	Agriculture and Natural Lands	Increase soil conservation practices on urban and agricultural lands
T1	Transportation	Increase the adoption of low and zero-emission vehicles by developing education, outreach, and planning materials for localities for purchasing and maintaining zero emission vehicles and develop a fueling infrastructure deployment strategy
T2	Transportation	Reduce VMT and support alternative modes of transportation through bike/pedestrian infrastructure investments
B1	Buildings	Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for local government and school buildings
B2	Buildings	Reduce energy consumption and increase building efficiency through programs to support, incentivize, and install weatherization and electrification measures in residential buildings
B3	Buildings	For C&I buildings, increase energy efficiency through financial incentives and educational outreach programs and strongly encourage the design, building, and operation of buildings above current required code
E1	Energy Supply	Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub
E2	Energy Supply	Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency
I1	Industry	Support emissions reductions from industrial processes
I2	Industry	Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes
W1	Waste and Wastewater	Decrease the amount of waste sent to landfills
W2	Waste and Wastewater	Support efficiency upgrades at wastewater treatment plants

Measure Development Process

Measures were developed through an iterative process with input from the Steering Committee, stakeholders, and community members at various stages. An initial draft list of measures was compiled from the previously completed PCAP report, a comprehensive document review of climate and related sustainability plans and commitments from localities and authorities within the Hampton Roads region, and input from the Steering Committee. Sample actions for each measure were identified from area plans and input on what could help address barriers, which were then shared, discussed, and further developed with stakeholders and community members. With this input, the measures and actions were refined and reviewed with the Steering Committee, producing the final list shown above.

Pathway to Net Zero

The identified measures are intended to help provide a pathway to net zero GHG emissions for the region by 2050, the long-term GHG reduction goal for this plan. Building from the BAU analysis, the potential for GHG emission reductions from each measure was assessed, creating the Net Zero Scenario. There are multiple ways for each sector to reduce emissions; this scenario provides just one illustrative path to show the opportunities and relative impact in each sector. In addition to the 2050 long-term goal, the near-term goal was maintaining the BAU GHG trajectory through 2035, which reduced gross GHG by 20% from 2022 and assumed continued successful implementation of existing programs and policies.

Figure 6 shows the region's GHG emission projections by sector. **Compared to the 2022 inventory base year, the pathway achieves a 92% reduction in net emissions by 2050**, with around 1.4 $MMTCO_2e$ of net GHG emissions remaining in 2050. This is on track to meet a longer-term net zero GHG reduction goal, with some additional activities needed to address the final remaining emissions, which may rely on emerging technologies or carbon capture. The pathway also surpasses the near-term goal, reducing gross GHG emissions 36% by 2035 from 2022 levels.

Figure 6: Hampton Roads MSA GHG Emissions by Sector: Net Zero Pathway Scenario

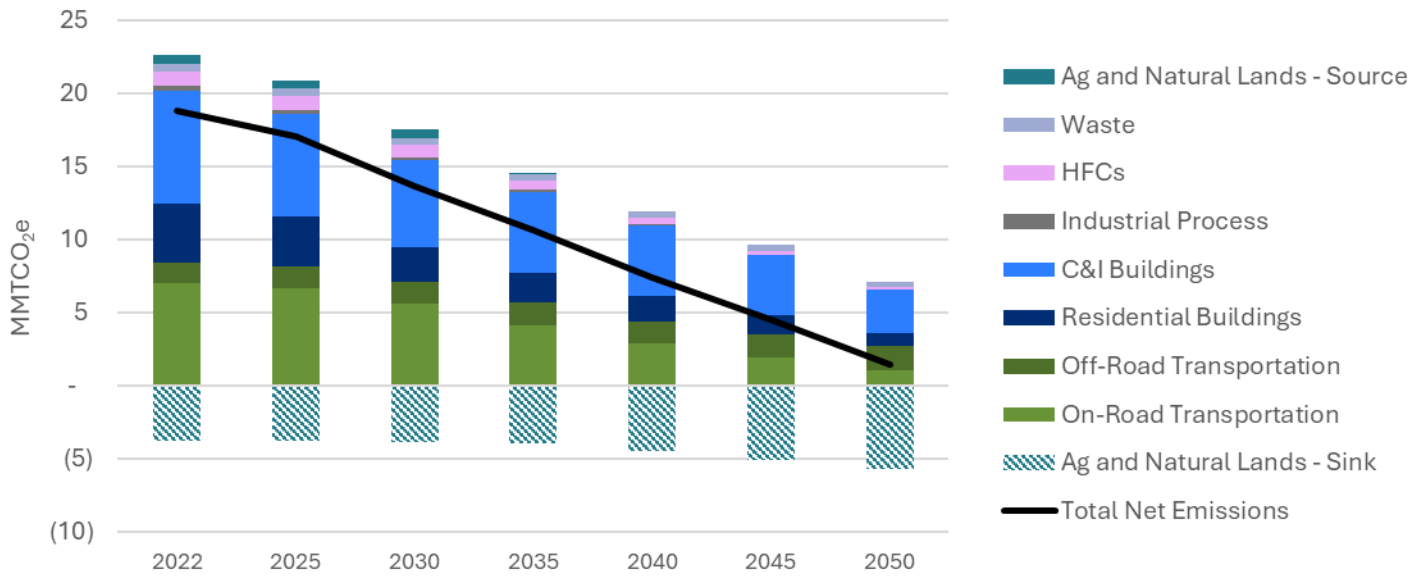


Figure 7 below presents the pathway to net zero scenario via a "wedge chart", which illustrates the impact on GHG reductions from each measure. The measures driving the largest GHG reductions for this pathway include:

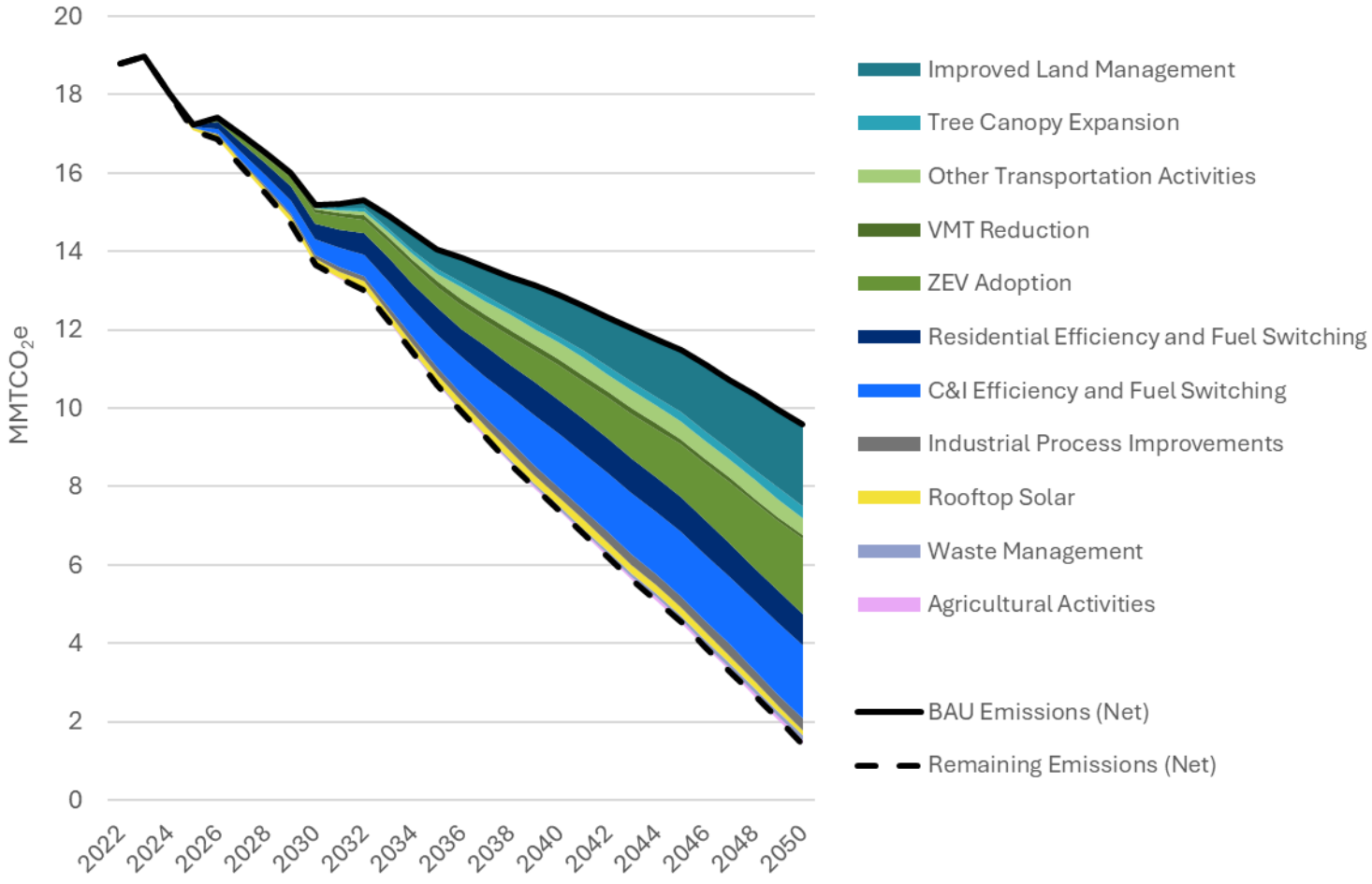
1. Increased sequestration protecting and restoring **wetlands** and **forest lands** results in the greatest cumulative GHG reductions from increased CO_2 sequestration.
2. Adoption of **zero-emission vehicles**. When paired with electricity powered by clean energy (as mandated by the Virgina Clean Economy Act), this strategy results in significant emission reductions across the region.
3. **Energy efficiency and electrification** of heating, cooking, and appliances in residential and commercial buildings. Similar to transportation, the region's expected clean grid is a key enabling factor for the reductions achieved by this measure.
4. The use of **low carbon fuels** like renewable natural gas to decarbonize fuel use in **industrial** facilities.

To present GHG reductions by measure, a “wedge chart” may be used in planning efforts to illustrate how different climate mitigation strategies impact GHG emissions over time. Each “wedge” represents a mitigation strategy (e.g., zero emissions vehicle (ZEV) adoption, urban tree canopy expansion, etc.) tied to the GHG measures list in Table 3. Some measures have been aggregated into wedges to simplify the chart. The chart shows the cumulative reductions from the various measures compared to the BAU Scenario.

The top line of the chart shows the BAU emissions and the bottom line shows the emissions under the Net Zero Scenario. The wedges in between represent the various ways to close the gap between the BAU and Net Zero Scenarios. The bigger the wedge, the bigger the impact of that measure. Taken together, the wedges are a visual tool to help understand how the multiple measures come together to achieve the plan’s goal of net zero GHG emissions by 2050.

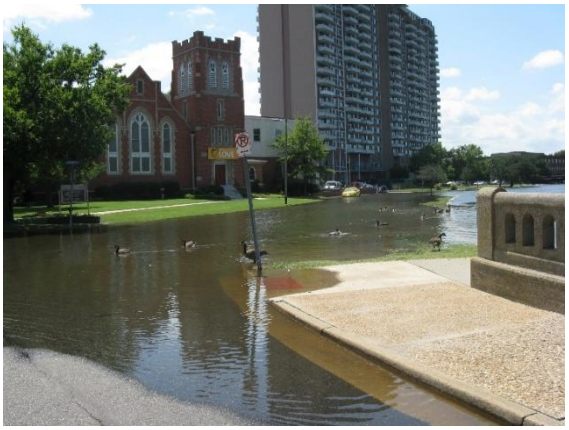
In order of magnitude, the agriculture and natural lands, transportation, and residential and commercial buildings sectors are the top three drivers of emission reductions, followed by industry and waste. The state’s targets for a net zero electric power sector are a key enabling strategy to support end-use electrification across the transportation, buildings, and industrial sectors without shifting emissions from those sectors to the power sector.

Figure 7: Net Zero Scenario: GHG Emission Reductions from Each Measure



Authority to Implement

This plan is a community-based effort that relies on the active participation and cooperation of local governments, businesses, non-governmental organizations, and residents. In many cases, public and private partners will need to collaborate to effectively implement measures. Every measure includes actions that can be implemented in the near term, where localities have clear authority to implement. Other actions may be best addressed at the state level – for example, both Virginia and North Carolina have restrictions in place that limit the ability for localities to set their own energy codes that go above and beyond state regulations. Regardless, by working together, communities in Hampton Roads can implement innovative solutions, share resources, and create a resilient and sustainable future for the region. The following is a summary of implementation authority by sector.



Flooded street in Norfolk, VA. Source: HRPDC

Agriculture and Natural Lands

Local governments lead implementation through planning and project execution, while state and federal agencies provide the regulatory framework, funding, and technical support needed for cross-jurisdictional projects and long-term monitoring. Private landowners and farmers will also need to opt into programs and work collaboratively with localities to implement many of the measures.

Local Authority. Local governments in both Virginia and North Carolina hold primary authority over land use, zoning, open space, and conservation planning, allowing them to adopt ordinances or incentives that protect natural resources and public health. Localities can establish tree planting programs, create and manage green infrastructure plans, and integrate wetland, forest, and coastal habitat protection into local comprehensive plans. They may also use zoning and land development codes to encourage or require conservation buffers, urban forestry, or pollinator-friendly projects such as agrivoltaics.

State Authority. State natural resource agencies, including Virginia Department of Conservation and Recreation (DCR), Virginia Department of Forestry (DOF), and North Carolina Department of Environmental Quality (NCDEQ), manage and regulate state lands, enforce conservation easement programs, and oversee wetlands, nutrient reduction, and coastal zone management programs. In both states, projects affecting tidal wetlands or coastal habitats require coordination and permitting under state and federal law (e.g., Virginia Marine Resources Commission or North Carolina Division of Coastal Management). States also manage soil and water conservation districts, which work closely with local governments and agricultural partners to promote soil conservation and regenerative practices.

Federal Role. Federal agencies such as the United States Department of Agriculture (USDA), through the Natural Resources Conservation Service and Forest Service, and National Oceanic and Atmospheric Administration (NOAA) provide funding, technical assistance, and conservation incentives through programs like the Conservation Reserve Program and Regional Conservation Partnership Program.

Atlantic Avenue Trolley in Virginia Beach. Source: HRPDC

Transportation

Local governments drive community-scale infrastructure and policy changes, while state and federal agencies control funding, fuel standards, and major transportation planning frameworks.

Local Authority. Local governments can procure and manage their own public vehicle fleets, enabling adoption of low- and zero-emission vehicles. They can adopt local EV-ready ordinances, zoning updates, and parking codes to facilitate charging infrastructure, and they may plan or invest in bicycle and pedestrian infrastructure and complete streets policies. Employers and local agencies can implement telework incentives and commuter benefits to reduce VMT. Some localities in Virginia maintain their road networks have ability to determine road and infrastructure design, whereas in other localities, that authority resides with the state.

State Authority. In Virginia, the Virginia Department of Transportation (VDOT) and Department of Rail and Public Transportation (DRPT) oversee highway, rail, and transit planning and funding, while the Virginia Department of Energy supports alternative-fuel deployment. In North Carolina, the North Carolina Department of Transportation (NCDOT) holds comparable powers, including management of state highways, regional transit programs, and coordination with Metropolitan Planning Organizations (MPOs). State agencies manage clean transportation incentive programs, EV corridor planning, and fuel infrastructure grants.

Federal Role. The U.S. Department of Transportation (USDOT) and Federal Highway Administration (FHWA) provide major funding and regulatory oversight for EV infrastructure (through the National Electric Vehicle Infrastructure (NEVI) program), transit capital projects, and pedestrian safety initiatives.

Hampton Roads Transit bus stop. Source: HRPDC

Passengers disembarking from The Tide light rail, operated by Hampton Roads Transit. Source: HRPDC

Waste

Local governments control daily operations and program design, while state and federal agencies provide permitting, enforcement, and financial assistance mechanisms.

Local Authority. Local governments are the primary actors in solid waste and wastewater management, with authority to establish and operate landfills, recycling centers, composting programs, and wastewater utilities. For solid waste management, localities may coordinate through regional service authorities such as the Southeastern Public Service Authority (SPSA). Localities can adopt diversion goals, recycling ordinances, and methane capture projects, and can improve wastewater energy efficiency through plant upgrades and methane recovery systems.

Hampton Roads Sanitation District (HRSD) is the primary implementing entity for regional wastewater process improvements, energy efficiency, and greenhouse gas reduction projects. HRSD owns and operates the regional interceptor system and 17 treatment plants. Local cities and counties manage the smaller local sewer collection systems that feed into HRSD's regional system. HRSD leads capital improvement projects for wastewater resilience, including sea level rise adaptation, energy efficiency upgrades, and nutrient removal improvements. A prime example of overlapping implementation authority, it operates under Virginia Department of Environmental Quality (DEQ) permits and federal EPA oversight under the Clean Water Act.

State Authority. In Virginia, VA DEQ regulates landfill operations, air and water quality, and waste permits; in North Carolina, the NCDEQ Division of Waste Management and Division of Water Resources serves similar roles. Both states set regulatory standards and approve permits for solid waste facilities, wastewater discharge, and infrastructure expansion.

Federal Role. EPA regulates landfill emissions and wastewater treatment standards under the Clean Air Act and Clean Water Act, and funds local improvements through State Revolving Fund (SRF) programs.

Buildings

State agencies define the code framework; localities operationalize it through implementation, voluntary initiatives, and public leadership; and private building owners are the key implementers of energy and carbon reduction improvements. Private building owners, property managers, and developers are the primary implementers of building energy improvements. They voluntarily participate in incentive programs, green building certifications, and energy benchmarking initiatives that go beyond minimum code requirements. Commercial and multifamily building owners can play a leading role by pursuing high-performance design and retrofits, electrification of heating systems, and installation of renewable energy technologies, often supported by state and federal incentives. Their participation is essential for achieving deep emissions reductions in the buildings sector.

Local Authority. Local governments oversee building permitting, inspection, and enforcement but must comply with state-adopted building and energy codes. In both Virginia and North Carolina, localities cannot adopt stricter building energy standards than those established by the state. However, they can:

- Lead by example by achieving net zero energy use in public buildings (B1).
- Implement voluntary programs and incentives for energy efficiency and electrification (B2, B3).
- Partner with utilities, energy service companies, and financial institutions to expand access to energy efficiency and weatherization programs for households and small businesses (B2, B3).
- Integrate energy performance requirements into procurement, contracting, or zoning for redevelopment projects (B2, B3).

State Authority. Virginia's Department of Housing and Community Development (DHCD) oversees the Uniform Statewide Building Code (USBC); North Carolina's Building Code Council and Department of Insurance administer the North Carolina Energy Conservation Code. Both states set minimum performance standards that localities must enforce.

Federal Role. Federal agencies such as the Department of Energy (DOE) and EPA provide incentives, grants, and model code support through programs such as ENERGY STAR and Home Energy Rebate Programs.

Industry

State and federal authorities set regulatory and funding frameworks; local governments influence siting and partnerships; and industrial facilities themselves are the main implementers of emission-reduction actions through voluntary participation and investment in cleaner operations. Industrial facility owner and operator participation in decarbonization efforts is largely voluntary, unless required by specific air quality or permitting regulations. Companies may engage in energy efficiency upgrades, process improvements, fuel switching, and renewable energy use through voluntary or incentive-based programs. Industry partnerships with utilities, local governments, and technical assistance programs are key to scaling adoption of clean manufacturing practices.

Local Authority. Local governments influence industrial emissions through zoning, siting approvals, tax incentives, and industrial park planning, and can support voluntary emissions-reduction initiatives (I1). For port operations (I2), local and regional port authorities can pilot low-carbon fuels and electrification initiatives with state and federal partners.

State Authority. In Virginia, DEQ regulates industrial emissions and permitting under the Air Pollution Control Law, while Virginia Energy manages clean manufacturing and industrial efficiency programs. In North Carolina, DEQ's Division of Air Quality

regulates industrial sources, and NC Department of Commerce and NCDEQ support industry modernization and energy programs.

Federal Role. EPA regulates greenhouse gas and criteria pollutant emissions from industrial sources under the Clean Air Act. DOE's Industrial Efficiency and Decarbonization Office (IEDO) funds efficiency and process innovations. The U.S. Maritime Administration (MARAD) supports port decarbonization initiatives.

Energy

State regulators and utilities hold primary authority over grid-scale energy planning and operation, while local governments influence siting, zoning, and community acceptance. Building owners, developers, and residents are the key implementers of rooftop and distributed solar, and local policies—such as streamlined permitting, financing assistance, and outreach—can substantially accelerate adoption. Effective clean-energy progress depends on alignment and cooperation across all levels: state and federal agencies set the framework; utilities and developers deliver infrastructure; and local governments and communities create the enabling environment for adoption.

Local Authority. Local governments play a key enabling and facilitative role in clean energy deployment but generally do not control energy generation or grid infrastructure. Their primary authorities include zoning, permitting, and local land use approvals, which directly affect where energy projects can be sited. Localities can:

- Streamline permitting and zoning for distributed solar and storage, particularly rooftop or community-scale installations (E1).
- Lead by example by installing solar or battery systems on public facilities and by adopting clean energy procurement policies for municipal operations (E1, B1).
- Designate renewable energy overlay districts or allow solar as a by-right use in certain zones (E2).
- Collaborate with regional planning agencies, utilities, and developers to evaluate grid capacity and resilience needs, supporting grid-scale projects while balancing community priorities and environmental protection (E2).

Private Sector and Utility Role. Utilities and private energy developers are the primary implementers of both grid-scale and distributed clean energy projects. For distributed solar (E1), private installers, building owners, and homeowners drive adoption through individual investments. Local permitting processes, interconnection policies, and incentive programs strongly influence participation. For grid-scale generation (E2), investor-owned utilities and independent power producers plan, finance, and operate solar, wind, and battery storage facilities. Their projects are subject to approval by state regulators (State Corporation Commission (SCC) in Virginia; North Carolina Utilities Commission (NCUC) in North Carolina). Developers must obtain local land use and siting approvals, often coordinating with local governments to address visual, environmental, and infrastructure impacts.

State Authority. State agencies and commissions regulate nearly all aspects of electricity generation, transmission, and distribution. In Virginia, the SCC oversees utility resource planning, grid infrastructure investments, and interconnection rules, while Virginia Energy administers renewable energy policy, grant programs, and technical assistance. In North Carolina, NCUC regulates investor-owned utilities and interconnection procedures, and NCDEQ's State Energy Office advances renewable energy and resilience initiatives. Both states have established renewable portfolio standards and clean energy planning requirements that shape market conditions for utilities and developers.

Federal Role. Federal agencies provide regulatory oversight and funding support for energy transition efforts. The Federal Energy Regulatory Commission (FERC) regulates interstate transmission and wholesale power markets. DOE funds clean energy research, grid modernization, and resilience projects, while EPA and USDA support renewable energy deployment through technical and financial assistance programs. The U.S. Treasury implements tax incentives (e.g., Investment and Production Tax Credits) that enable both grid-scale and rooftop solar development.

Funding Sources

The following section identifies potential funding sources by sector for implementation of the GHG reduction measures. While this section focuses primarily on federal and state programs, additional support may also be available through utilities, green banks, philanthropic organizations, and public-private partnerships. Many of the listed programs can be combined to finance projects that deliver multiple co-benefits, such as improved air quality, resilience, and community well-being. Access to funding will vary depending on the scale of the project, the eligible applicant (e.g., local government, nonprofit, business, or regional entity), and the ability to provide matching funds or meet technical criteria. Effective implementation often depends on coordinating multiple funding streams to achieve complementary outcomes.

Federal Funding Uncertainty

While federal programs provide the largest source of climate and infrastructure funding, many are subject to future budget appropriations and policy shifts. Changes in federal priorities or administrative actions may alter program timelines, eligibility criteria, or total available funding, underscoring the importance of maintaining diversified and flexible funding and financing strategies. Many key initiatives, such as those created under the Infrastructure Investment and Jobs Act and Inflation Reduction Act, have already been rolled back under the current federal administration. Given the continued high level of uncertainty in the status of many federal programs, any potential applicants should verify program status, eligibility, and available funding at the time of application and consider alternative funding and financing mechanisms to mitigate risk from potential reductions or pauses in federal support.

Leveraging Partnerships and Blended Finance

Because few projects are fully funded by a single source, successful implementation often depends on blended finance, which means combining grants, loans, tax credits, and private capital to meet total funding needs. Local governments can align multiple funding sources through coordinated capital planning or regional grant consortiums.

Public-private partnerships (P3s) and green bank financing can fill remaining gaps, especially for distributed energy, fleet electrification, and building retrofit projects that yield long-term cost savings. Utilities and regional authorities can act as anchor partners, channeling investments through existing programs or joint infrastructure projects. In addition, philanthropic and community-based funding can provide early-stage resources for planning, community engagement, and capacity-building. These are critical steps that position localities and nonprofits to compete effectively for larger state and federal awards. Together, these funding strategies create a resilient foundation for long-term implementation of the region's climate and energy measures.

Natural & Working Lands

Projects that protect and restore forests, wetlands, and coastal ecosystems or support sustainable agriculture and local food systems are eligible for a range of federal conservation and environmental education grants. State programs in Virginia and North Carolina complement these efforts by supporting community forestry, watershed protection, and reforestation.

Example potential funding sources include:

- USDA Natural Resources Conservation Service (NRCS) – Healthy Forests Reserve Program
- National Forest Foundation – Grant Programs for forest restoration and community engagement
- U.S. Forest Service – Urban and Community Forestry Grants
- Virginia Department of Forestry (DOF) – Trees for Clean Water Grant Program

- Virginia DOF – Forest Pest Treatment Cost-Share Programs
- Virginia DOF – Community Forest Revitalization Program
- NOAA Chesapeake Bay–Watershed Education and Training (B-WET) Program
- Chesapeake Bay Trust – Environmental Education Grant Program
- Virginia DCR – Watershed Educational Programs Project

Many of these programs can fund tree planting (NWL1), soil conservation (NWL3), and environmental education initiatives that strengthen community-based climate action (NWL2).

Transportation

Transportation decarbonization projects such as fleet electrification, transit expansion, EV charging infrastructure, and active transportation investments are supported by numerous federal transportation and energy programs, often administered through state departments of transportation or MPOs. Many require local match funds or alignment with regional transportation improvement plans.

Example potential funding sources include:

- Federal Transit Administration (FTA) – Urbanized Area Formula Program
- FTA – Bus and Bus Facility Grants
- FTA – Capital Investment Grants
- FHWA – Carbon Reduction Program
- FHWA – Congestion Mitigation and Air Quality Improvement (CMAQ) Program
- FHWA – Highway Safety Improvement Program (HSIP)
- FHWA – Surface Transportation Block Grant (STBG) Program
- FHWA – NEVI Formula Program
- FHWA – Charging and Fueling Infrastructure Discretionary Grants
- EPA – Clean School Bus Program
- EPA – Diesel Emissions Reduction Act (DERA) Program
- EPA – Clean Heavy-Duty Vehicle Program
- FTA – Low or No Emission Vehicle Grant Program
- IRA – Alternative Fuel Vehicle Refueling Property Tax Credit
- USDA – Rural Energy for America Program (REAP): Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants
- Virginia DRPT – Transit and multimodal funding programs

CPRG Implementation Grant Award

In July 2024, EPA awarded a **$421 million** CPRG Implementation Grant to the Atlantic Conservation Coalition (ACC), a multi-state partnership led by the North Carolina Department of Natural and Cultural Resources and including the states of Virginia, South Carolina, and Maryland, together with The Nature Conservancy. This award is dedicated to protecting and restoring high-carbon natural and working lands including forests, peatlands, and coastal wetlands in order to increase carbon sequestration, reduce greenhouse gas emissions, and improve climate resilience across the region. This grant offers a major opportunity for local governments, land trusts, agricultural landowners, and community partners in both North Carolina and Virginia to collaborate on projects that align with existing state-level NWL goals while scaling up restoration and conservation of carbon-rich habitats.

- Virginia Commuter Assistance Program (CAP)
- Virginia Ridership Incentive Program (VRIP)
- Mobile Sources Emissions Reduction Grant Program (via North Carolina Department of Environmental Quality)

Together, these funding streams can support T1 (EV adoption and fueling infrastructure) and T2 (multimodal and transit investment) measures at the local and regional scale.

Buildings, Energy, and Industry

Energy efficiency, electrification, and industrial decarbonization measures can be funded through a mix of DOE, EPA, and state-level programs, as well as tax incentives, utility rebates, and mechanisms such as Property Assessed Clean Energy (PACE) financing. These resources are applicable across building, energy, and industry measures (B1–B3, E1–E2, I1–I2).

Example potential funding sources include:

- U.S. DOE – Energy Efficiency and Conservation Block Grant Program (EECBG)
- DOE – Home Efficiency Rebates and Home Electrification and Appliance Rebates
- DOE – State Energy Program
- DOE and State Agencies – Weatherization Assistance Programs
- DOE – Grid Innovation Program
- DOE – Smart Grid Grants
- DOE – Grid Resilience and Innovation Partnerships (GRIP) Program
- U.S. Department of Health and Human Services (DHHS) – Low Income Home Energy Assistance Program (LIHEAP)
- Inflation Reduction Act (IRA) – Energy Efficient Commercial Buildings Deduction (Section 179D) and New Energy Efficient Home Credit (Section 45L)
- Virginia PACE – Commercial energy efficiency financing
- Virginia Clean Energy Innovation Bank – Low-cost financing for clean energy and efficiency projects
- Virginia Grid Reliability Improvement Program
- Virginia Community Access to Renewable Energy Funding
- North Carolina DEQ - Energy Saver North Carolina Rebate Program
- Utility Energy Efficiency and Electrification Programs

Collectively, these resources can support local and private-sector implementation of energy efficiency retrofits, electrification, distributed solar deployment, grid modernization, and industrial process improvements. Many programs prioritize projects that reduce emissions while improving grid resilience and energy affordability.

Home Energy Rebates

Created under the Inflation Reduction Act (IRA), the Home Energy Rebates initiative provides two complementary programs designed to help households reduce energy use and lower costs. The **Home Efficiency Rebate Program (HOMES)** rewards whole-home energy upgrades such as insulation, air sealing, and equipment replacement based on verified energy savings. The **Home Electrification and Appliance Rebates (HEAR)** program offers point-of-sale rebates for replacing fossil-fuel appliances with efficient electric alternatives like heat pumps, induction cooktops, and heat-pump water heaters.

North Carolina launched its combined **Energy Saver NC** program in early 2025 with more than $208 million in federal funding, providing rebates of up to **$16,000 per household** for comprehensive upgrades and up to **$14,000 for appliance-based electrification. Virginia** has received approximately $188 million in federal allocations and is finalizing its program plan.

Together, these programs represent one of the largest residential energy-efficiency investments in U.S. history, offering substantial opportunities for homeowners to cut utility bills, improve comfort, and advance building decarbonization across the region.

Waste and Wastewater

Waste reduction, recycling, and wastewater efficiency projects can draw from both EPA and USDA programs, supplemented by state-level recycling, litter prevention, and infrastructure grants. For Hampton Roads, SPSA and HRSD can also leverage federal and state programs for solid waste diversion and wastewater treatment upgrades (W1–W2).

Example potential funding sources include:

- EPA – Solid Waste Infrastructure for Recycling Grant Program
- EPA – Consumer Recycling Education and Outreach Grant Program
- USDA – Solid Waste Management Grants
- USDA – REAP Guaranteed Loans and Grants
- Virginia DEQ – Litter Prevention and Recycling Grants
- North Carolina DEQ – Solid Waste and Recycling Grant Program
- Virginia and North Carolina DEQ – State Revolving Loan Funds

Additional opportunities may arise through state revolving funds (Clean Water SRF) for wastewater infrastructure improvements, particularly projects that incorporate methane capture, energy efficiency upgrades, or resource recovery systems.

Guide to the GHG Measure Templates

The following sections present information for each GHG reduction measure, including:

- Sector overview: Summary of the sector's main sources of emissions, relevant measures, and implementation partners.
- Measure name and description: Summary of the purpose of the measure and actions.
- Co-benefit icons: Next to each measure name, the icons indicate whether that co-benefit is applicable. Indicators include improved health outcomes, improved air quality, improved water quality, increased resilience to climate impacts (community resilience, extreme heat, flooding, etc.), improved habitat and biodiversity, GHG reductions, and relative costs. For more information on GHG reductions and measure costs, see Appendix B.

- Key Actions: Specific steps and project examples to implement the measure. Actions are a menu of options for implementers to consider going forward and can be applied as relevant to a locality's context to meet their specific needs.
- Key Implementers: Potential organizations and entities that may have a role in measure implementation.
- Metrics for Tracking Progress: Sample metrics that could be used to monitor progress over time. Not all suggested metrics may have data available to gather today.

Hampton Roads Climate Action Plan
NATURAL LANDS

Natural Lands Are a *Sink* for Greenhouse Gases

Sinks are processes and systems that *sequester and store* carbon dioxide and other greenhouse gases. Hampton Roads' main greenhouse gas sinks are:

FORESTS, WETLANDS, & URBAN TREES are responsible for offsetting approximately **3.8 million metric tons** of carbon dioxide yearly. This is equivalent to the emissions from...

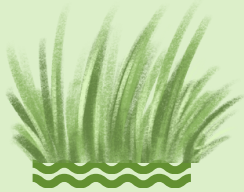
900,000 passenger cars powered for 1 year

or **500,000 homes** powered for 1 year

Tree Canopy Coverage in Hampton Roads localities ranges **between 25% to 65%.**

Tree canopy is being lost in the region, on average **~70 acres** per locality, per year.

Wetlands account for **32%** of the land cover in the region.



Hampton Roads **loses ~ 800 acres of wetlands** per year.

VOICES HEARD AROUND THE REGION...

"Increased green space and restoring tree populations could help address increased heat, storm water runoff and carbon sequestration..."

"Trees are one of the easiest ways to help offset/cope with carbon emissions. In addition to switching to more renewable energy, hybrid/electric vehicles, and developing climate resiliency plans, please support the creation of more green spaces."

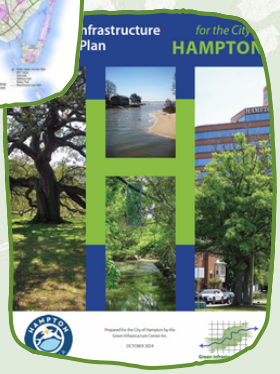
How Hampton Roads Can Increase Natural Lands to Reduce Emissions

ACTION	WHAT IT MEANS	KEY BENEFITS
Expand Tree Canopy & Green Space, & Restore Wetlands	Plant and maintain trees in cities and neighborhoods, construct living shorelines	Cooler streets, improved air quality, flood prevention, property value gains
Support Local Food Systems	Strengthen local farms, gardens, and markets to promote sustainable food production and reduce emissions from long-distance transport	Builds local resilience, supports regional food access, keeps farmland productive, and reduces transportation emissions

BUILDING UPON REGIONAL SUCCESSES

James City County Tree Seedling Giveaway Program

Green & Natural Infrastructure Plans developed by Norfolk, Hampton, Suffolk, & others



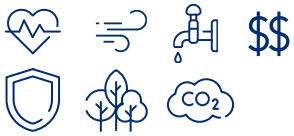
York County supports local food production & urban agriculture with community gardens

Living shoreline projects installed across the region

Agriculture and Natural Lands Sector

Agriculture and natural lands can both release GHG emissions and function as a sink, sequestering and storing carbon dioxide and other GHG emissions. Actions in this sector focus on conserving, restoring, and managing lands to preserve and enhance their benefits – such as wetland and living shoreline restoration and increased tree canopy – and aim to increase soil conservation practices on urban and agricultural lands, support local food production, and promote urban agriculture. Implementing these measures will help reduce GHG emissions, increase carbon sequestration, and enhance community protection from storms and flooding, contributing to overall climate resilience.

NWL1. Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands



A native tree seedling giveaway program organized by James City County, VA.
Source: James City County, VA Climate Solutions Roundtable Presentation.

Actions to increase carbon sequestration in Hampton Roads reflect four primary approaches: expansion, conservation, restoration, and promotion of planning practices that support the health and function of natural lands. Focused on urban tree canopy and green space, green infrastructure planning and implementation, and large-scale living shoreline and stream restoration and conservation, these actions have many co-benefits in addition to reducing GHG emissions. Conservation of natural lands protects and restores high-carbon coastal habitats, wetlands, and forest lands. Expanding the urban tree canopy and green space can reduce urban heat islands, improve air quality, and enhance the aesthetic appeal of urban areas. Large-scale living shoreline and stream restoration efforts help stabilize coastlines, reduce erosion, and enhance habitats. Promoting green infrastructure planning and implementation ensures that urban areas incorporate sustainable practices, such as green roofs and permeable pavements, which can contribute to overall improved environmental quality and climate resilience. In Hampton Roads, localities within the Chesapeake Bay watershed have an average tree cover of 49%, resulting in 2M metric tons of carbon sequestration.

“Increased green space and restoring tree populations could help address increased heat, storm water runoff, and carbon sequestration...” – Survey response

Key Actions

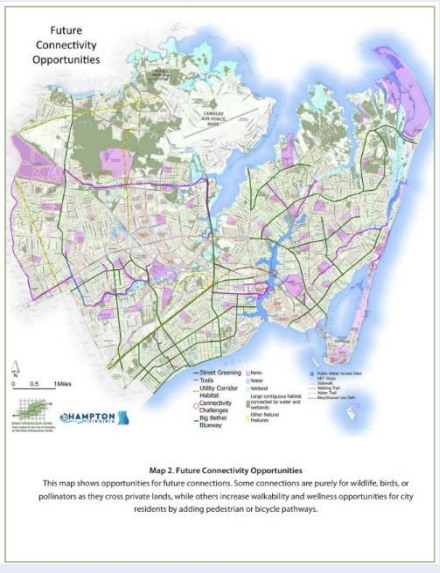
- **Expand Urban Tree Canopy and Green Space**
  - Develop tree canopy inventories, and/or urban forestry management plans. Use these tools to establish expansion goals and identify implementation strategies for tree canopies in urban areas.
    - The Chesapeake Bay Program has developed tree canopy fact sheets for many of the localities in the MSA, providing a snapshot in time of urban tree canopy change to inform how loss and subsequent gain can be achieved. If more refined data needs are required by localities, they can also partner with the Green Infrastructure Center to conduct an inventory and set goals similar to Norfolk's Green Infrastructure Plan or Suffolk's Green Infrastructure Pla for the Nansemond River Watershed.
    - Localities can collect their own tree canopy data (see Norfolk's City Tree Inventory) or develop their own tree canopy and/or forest management plans like Virginia Beach's State of the Urban Forest report.
    - Consider a regional approach to mapping urban heat islands to communicate, educate, and potentially mitigate the impacts of extreme heat, like Plan RVA's Richmond Region Urban Cooling Capacity Analysis Project and building on HRPDC and HRTPO's Shady Stops survey map of tree canopy at bus stops.
    - Leverage the VA Department of Forestry's Community Assistance for Urban and Community Forestry to educate and provide funding for tree planting and local program development. Identify lessons learned from previous successful programs in Norfolk and Virginia Beach.
    - Review the VA DOF's first statewide Forestland and Urban Tree Canopy Conservation Plan when released (expected November 2026). Identify regionally-specific information and actions appropriate for the Hampton Roads area.
    - For Hampton Roads localities, replicate Chesapeake Bay Foundation's (CBF) tree canopy and green space initiatives in Hopewell: Expand urban tree planting efforts in low-income areas to improve air quality, reduce heat, and prevent runoff. Train and engage local volunteers through tree steward programs to maintain planted trees. Hopewell Restoration Project - Chesapeake Bay Foundation
    - Participate in the Southeast Virginia Urban Forest Roundtable to share best practices and learn about what other localities and volunteer groups are doing regionally.
  - Consider partnering with non-profit organizations to retrofit parking lots to provide more tree canopy coverage.

Local Green Infrastructure Plans

The Cities of Norfolk and Hampton have established Green Infrastructure Plans. Through partnerships with the Green Infrastructure Center, they identified green assets, established goals to increase natural infrastructure, and prioritized highest value natural resources to protect.

Map of the Future Green Infrastructure Network in Norfolk

Map of the Future Green Infrastructure Network in Hampton



- Raise awareness and partner with non-governmental organizations (NGOs) about the threats of invasive species to urban forests and parks. Outreach could be focused on removal and adhering to a new law (HB1841/SB1166) that informs consumers on the purchase of invasive species (effective Jan. 1, 2027).
- Encourage localities to establish a tree canopy fund by ordinance to collect, maintain, and distribute fees collected from developers pursuant to new legislation (HB2630). Support future legislation to expand local government authority to conserve or replace trees during development, currently only allowed in northern Virginia.
- Consider partnering with the Department of Defense (DoD) to enhance urban tree canopy in and around installations. Use the Tidewater Sentinel Landscape initiative to pilot this effort and include outreach and education on the benefits to mitigating urban heat islands and improvements to quality of life for military service members and their families.
- Establish policies and guidelines for existing and new roadways for tree planting in street medians and interstate reforestation. Localities are enabled to adopt tree conservation ordinances and can regulate the preservation and removal of trees within public rights-of-way, but there are no requirements for planting.
- Encourage VDOT to adopt a requirement for tree planting along interstate corridors.

- **Promote Green Infrastructure Planning and Implementation**
  - Using existing local green infrastructure plans as examples (Norfolk and Hampton), partner with the Green Infrastructure Center or other entities to incorporate green infrastructure planning into resilience and development plans.
  - Promote green infrastructure best management practices (BMPs) for stormwater management in localities.
  - Use the Native Plants for Southeast Virginia plant guide in planting plans.
  - Consider more partnerships between localities and universities, like students from Christopher Newport University (CNU) and the Newport News Green Foundation, to develop partnerships and outreach to identify where residents would like to see green space.
  - Share experiences and support localities seeking funding for the Bloomberg American Sustainable Cities initiative.

Participating in the Bloomberg American Sustainable Cities Initiative

Hampton and Newport News have received funding to pilot projects in underserved areas to address innovative approaches to climate resilience and economic development.

"Focus on wetlands restoration + preservation, working with local Indigenous tribes + providing land back..."
– Survey response

- **Increase Conservation and Carbon Sequestration**
  - Using data gathered from localities and through other state tools like the Virginia Natural Landscape Assessment (VaNLA), and the Conserve Virginia 3.0 tool, update and expand on the 2006 Hampton Roads Conservation Corridor Study. This effort would go beyond habitat corridors to identify and prioritize large ecological cores for protection, ensuring that conservation efforts focus on areas with the highest ecological integrity.
  - Enhance connectivity to mitigate habitat fragmentation by implementing conservation strategies that maintain and restore landscape corridors, ensuring that ecological cores remain connected to support biodiversity and ecosystem resilience.
  - Consider local adoption of Purchase of Development Rights (PDR) programs.
    - James City County established a voluntary PDR program in 2001, allowing landowners to sell their development rights to the County, permanently preserving agriculture and forest land.

- Support ongoing state and local efforts to restore and enhance wetlands, coastal lands, and coastal estuaries.
  - Use the Virginia Wetlands Action Plan and its tracking and strategic planning to identify critical areas for facilitating the growth and preservation of wetlands. Identify priority projects in locality resilience plans that overlap with identified wetlands in the Action Plan to conserve open space, mitigate flooding, and protect vital habitats.
  - Provide continued support and outreach towards the implementation of VA DEQ's Chesapeake Bay Phase III Watershed Implementation Plan which identified hundreds of acres available for wetland restoration.
  - Wetlands Watch has developed guidance, Wetlands Migration Planning, to help raise awareness of the threat to coastal wetlands due to sea level rise, and offer solutions to protection, restoration, and enhancement.
- Promote conservation by enabling all local governments to enact cluster development ordinances, currently limited to only high-growth local governments as detailed in a 2022 report prepared for the VA General Assembly, A Study of Tree Conservation and Preservation in Development.

- **Support large-scale Living Shoreline and Stream Restoration and Conservation**
  - Implement living shoreline and stream restoration projects by stabilizing eroding stream channels near schools and parks, reconnecting floodplains, and using native vegetation to improve water quality. Conduct an analysis of all implementation projects proposed through Chesapeake Bay Total Maximum Daily Load (TMDL) Action Plans.
  - Leverage projects from CBF, James River Association, the Elizabeth Decade (or century) moratorium on development at/along the Dismal Swamp and other wetlands.
  - Identify funding sources and resources to continue implementation of living shoreline projects throughout the region as identified in DEQ's Phase III Watershed Implementation Plan (WIP).

Coastal habitat in Poquoson, VA. Source: City of Poquoson 2025 Climate Summit Presentation.

  - Promote community conservation landscaping by collaborating with local non-profits to promote workshops and provide residents with native plants to create rain gardens and conservation corners that reduce runoff and enhance biodiversity.
  - Expand environmental education programs by training local teachers in watershed science and implementing NOAA's Meaningful Watershed Education Experiences (MWEEs) in schools to engage students in conservation.

Key Implementers

- **Local governments and municipalities.** Operate land and conservation programming and policies within their jurisdictions. These entities can also support tree planting programs and goals.
- **Virginia DEQ.** Provides programming, funding opportunities, and technical assistance in conservation and maintenance of natural and working lands.
- **Virginia DOF.** Provides programming, funding opportunities, and technical assistance for forest conservation.

- **DCNR.** Provides programming, funding opportunities, and technical assistance in conservation and maintenance for Virginia's state parks and natural area preserves.
- **Local universities.** Studies on carbon reductions from natural sequestration and capture can support funding and potential programming.
- **Local non-governmental environmental organizations.** The Nature Conservancy, the Sierra Club, CBF, Wetlands Watch, James River Association, Elizabeth River Project, Virginia Forestry Association, and other NGOs provide programming, funding opportunities, and technical assistance in conservation and maintenance of natural and working lands.
- **Private sector partners.** Private landowners will be key partners for implementing changes to land use and forestry practices on their land to increase the region's carbon sequestration capacity.
- **Local organizations and nonprofits.** Local and community-based organizations and nonprofits provide valuable insight into strategically positioning trees to support communities.

Metrics for Tracking Progress

- Acreage of implemented BMPs
- Number of trees planted
- Number of oyster reefs restored (acres of reef habitat)
- Linear feet of living shorelines or stream restoration projects implemented
- Acres of wetlands restored, enhanced, or built
- Number of volunteers engaged in tree stewardship, invasive species removal, and habitat restoration
- Number of educational programs conducted (teacher trainings, student watershed programs)
- Number of urban forestry plans created
- Tons of CO_2e sequestered from baseline
- Percent of green space in restored and preserved natural lands
- Percent increase in tree canopy in urban and suburban areas
- Reduction in stormwater runoff
- Reduction in pollutants
- Increase in biodiversity (species counts in restored wetlands and forests)
- Reduction in heat island effect in urban areas with expanded tree canopy

Protection from Shoreline Erosion

NWS Yorktown and REPI partners are restoring the Penniman Spit from further erosion (86% of its area has been lost since 1937).

- The project will protect over 2,900 linear feet of shoreline by using natural and artificial oyster reefs
- NWS Yorktown is also protecting its training activities by acquiring restrictive easements on properties that have ties to the Civil and Revolutionary Wars

Source: US Department of Defense, Readiness and Environmental Protection Integration Program (REPI)

Protection and Management in James City County

The James City County Natural & Cultural Assets Plan was created to assist the county with prioritizing and conserving its resources, some of which includes:

- **12,800** acres of water and wetland area
- **500** miles of streams
- **140** cultural/historical points

NWL2. Support local food production, urban agriculture, and farm-to-school initiatives

Developing an active and productive local food system supports food production within the region and connects the community to regional and urban agriculture. Urban agriculture spaces, farmers markets, and farm-to-school initiatives that bring fresh produce into school meals and introduce students to farming and growing food, can have health and air quality co-benefits, increase food access, and strengthen the local agriculture economy.

Key Actions

- **Create school and community educational programs to support local food production**
  - Encourage localities to collaborate with community groups and schools to provide education on the impacts that different types of food production, processing, and transport can have on GHG emissions.
  - Encourage local school districts to join the Virginia Farm to School program to incorporate locally produced foods in student meals.
  - Add gardens in at least 5 public schools by 2030 and establish gardens in all public schools by 2050. Expand school gardens beyond James City County, Virginia Beach, and Norfolk, as shown in the FeedVA Home map.

York County, VA is supporting local food production and urban agriculture with two community gardens and other community initiatives. Source: Peninsula Area Climate Solutions Roundtable Presentation.

  - Partner with the Hampton Roads Hampton Roads Urban Agriculture group to educate communities and provide more opportunities to access healthy food.
- **Develop policies to strengthen local food production including more markets and policies to encourage urban gardens**
  - Map and track urban agriculture opportunities throughout the region to identify gaps in availability spatially and/or throughout the year.
  - Develop urban agriculture policies to advocate for zoning laws and incentives that support community gardens, rooftop farms, and small-scale urban agriculture.
  - Promote hydroponics and aquaponics to expand food production in urban areas with limited space.
  - Expand farmers' markets and local food hubs to strengthen local food supply chains by supporting farmers markets, community-supported agriculture (CSA) programs, and food hubs that connect producers with institutional buyers.
  - Increase local food procurement by setting targets for public institutions (e.g., schools, hospitals, government facilities) to source a percentage of their food locally.
  - Consider development of an agrivoltaics land use policy, allowing agricultural land use while generating power.
  - Increase food access and reduce food miles in underserved communities.
  - Expand pollinator resources by working with state and local honeybee organizations.

Key Implementers

- **Local governments and municipalities.** Develop and implement policies and programs to support urban agriculture, community gardens, and local food production. Facilitate farm-to-school initiatives within their jurisdictions.
- **Virginia Tech's Virginia Cooperative Extension.** Provide technical assistance, education, and resources to support urban agriculture and local food production. Offer programs and workshops for farmers and community members.
- **Local universities.** Conduct research on sustainable agriculture practices, urban farming, and local food systems. Support farm-to-school initiatives through educational programs and partnerships with local schools.
- **Local non-governmental environmental organizations.** Organizations like CBF, Virginia Food System Council, and other NGOs provide programming, funding opportunities, and technical assistance to support urban agriculture and local food production
- **Local school districts.** Implement farm-to-school programs, incorporating locally grown produce into school meals and providing educational opportunities for students about agriculture and nutrition.
- **Community-based organizations and nonprofits.** Support urban agriculture projects, community gardens, and local food initiatives. Provide resources, education, and volunteer support to enhance local food systems.
- **Private sector partners.** Collaborate with local farmers, food producers, and businesses to support local food production and distribution. Partner with schools and community organizations to promote farm-to-school initiatives.
- **Farmers and urban growers.** Engage in sustainable farming practices, participate in local food markets, and collaborate with schools and community organizations to support farm-to-school programs.

Food Insecurity in Hampton Roads

In 2018, **1 in 10 households** in Hampton Roads experienced "food insecurity." This rate fluctuates between cities and in 2018, Franklin experienced the highest rate of food insecurity at 14.6% (source: Food Insecurity in Hampton Roads). Programs such as Supplemental Nutrition Assistance Program (**SNAP**), Special Supplemental Nutrition Program for Women, Infants, and Children (**WIC**), and National School Lunch Program (**NSLP**) all help combat food insecurity.

Food Distribution Point. Source: ODU

School gardens are an additional resource that provide produce to local communities in Chesapeake, James City County, Virginia Beach, and Norfolk. School gardens are shown on the FeedVA Home map.

Metrics for Tracking Progress

- Number of schools with on-site gardens
- Number of Farm-to-School meal programs implemented
- Volume of locally sourced food integrated into school meals
- Increase in student access to fresh, local produce (%)
- Reduction in food miles traveled and associated carbon emissions (tons CO_2e)
- Percentage increase in urban green spaces dedicated to food production
- Improved food security metrics in participating communities
- Increase in local food system resilience (measured by local food production as a share of total consumption)

NWL3. Increase soil conservation practices and methane reduction on urban and agricultural lands

Active and healthy soils sequester GHG emissions and support strong agricultural and landscape industries. Conservation practices in agriculture and pasture lands can retain and improve soil quality, reducing the need for chemical-based fertilizers, preventing erosion, and lessening runoff into waterways. Actions in this measure aim to improve the health of soils, expand understanding of their benefits, and support integration of best practices for managing livestock grazing and pasture lands.

Key Actions

- **Research and promote soil health on agricultural lands**
  - Employ the help of soil health experts at the Hampton Roads Agriculture Research and Extension Center (AREC) to better understand the implications of poor soil health in agricultural fields on GHG emissions.
  - Work with local Soil, Water, and Conservation Districts (SWCDs) to:
    - Reduce nitrogen emissions from soil through soil testing, precision application, and use of slow-release fertilizers.
    - Maximize crop rotation and cover cropping practices to fix nitrogen.
    - Shift to low- or no-till farming.
    - Coordinate with DCR for more widespread implementation of nutrient management plans (NMPs) for public and private agriculture lands.
    - Use cover crops to plant rye, clover, or radishes in off seasons to prevent soil erosion, fix nitrogen, and enhance microbial life. More resources can be found here: Regenerative Agriculture's Top Eight Conservation Practices - Chesapeake Bay Foundation.
- **Research and promote soil health on highly compacted, urban lands**
  - With the help of soil health experts at the Hampton Roads AREC or SWCDs, to develop outreach and education materials on the effects of high soil compaction. Soil compaction can reduce the ability for landscapes to support trees and plants, increasing runoff volume, and providing no carbon sequestration.
  - Conduct Soil Profile Rebuilding (SPR) in public urban spaces to rehabilitate compacted soils and promote growth through reactivating biological activity in the soil.
  - Compare and contrast SPR efforts to identify best practices for unique conditions, i.e. consider topdressing, vertical mulching, hydraulic fracturing, or air tillage in various urban landscapes.
  - Partner with the Chesapeake Bay Landscape Professionals program to develop a monthly regiment that can be implemented by property owners. Landscaping companies could market a monthly regiment that could be an alternative to traditional techniques, and include composting amendments, aeration, mulching, etc.
  - Add soil amendments or compost to promote infiltration in compacted urban soils.
- **Improve manure and feed management practices to reduce methane**
  - Install digesters to capture methane produced during manure storage.
  - Store manure in covered composting facilities or biodigesters to reduce runoff and methane emissions. Apply composted manure to fields at optimal times for soil uptake.
  - Adopt the use of feed additives to reduce the amount of methane produced by livestock during digestion.

- **Increase tree planting on livestock grazing lands**
  - Implement silvopasture practices to integrate trees into grazing areas to improve livestock health, reduce polluted runoff, sequester carbon, and enhance soil health.
  - Establish streamside forest buffers by planting native trees and shrubs along waterways, maintaining at least a 35-ft buffer. These absorb runoff, prevent erosion, and provide habitat.
- **Support farmer to farmer outreach for grazing and pasture management**
  - Leverage CBF's Mountains-to-Bay (M2B) Grazing Alliance to:
    - Support sustainable farming by promoting rotational grazing and related conservation practices.
    - Provide outreach and technical assistance through farmer-to-farmer mentoring, on-farm demonstrations, and peer-to-peer experiences.
    - Explore mechanisms to ensure the longevity of the M2B Grazing Alliance beyond the grant period.
  - Convert cropland to pasture and implement rotational grazing by transitioning degraded cropland to perennial grasses, then divide pastures into paddocks and rotate livestock every few days. This prevents overgrazing, improves soil structure, and enhances carbon sequestration.
- **Advocate for funding incentives for agricultural management practices to reduce greenhouse gas emissions and farmland erosion**
  - Advocate for the support of the DCR Ag Incentives Program and other state funding to buffer creation and support, and precision nutrient application.
  - Advocate for continued funding of agricultural cost-share funding for BMP implementation throughout the Commonwealth.

Key Implementers

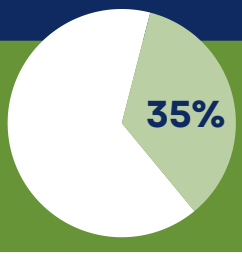
- **Local governments and municipalities.** Develop and implement policies and programs to promote soil conservation practices. Provide incentives and support for farmers adopting sustainable soil management techniques.
- **Virginia Tech Virginia Cooperative Extension.** Offer technical assistance, education, and resources to farmers on soil conservation practices. Conduct workshops and training sessions on sustainable agriculture and soil health.
- **Local universities.** Conduct research on soil conservation methods and sustainable agriculture practices. Provide outreach and education to farmers and the community on the benefits of soil conservation.
- **Local non-governmental environmental organizations.** Organizations like CBF and Virginia Association of Soil and Water Conservation Districts provide programming, funding opportunities, and technical assistance to support soil conservation efforts.
- **Local conservation districts.** Work directly with farmers to implement soil conservation practices. Provide technical assistance, cost-share programs, and resources to support sustainable soil management.
- **Private sector partners.** Collaborate with farmers and agricultural businesses to promote soil conservation practices. Provide funding, resources, and support for sustainable agriculture initiatives.
- **Farmers and agricultural producers.** Adopt and implement soil conservation practices on their farms. Participate in educational programs and collaborate with local organizations to enhance soil health and sustainability.

Metrics for Tracking Progress

- Acres of farmland using precision nutrient management
- Number of methane digesters installed and tons of methane emissions reduced
- Acres of cropland converted to rotational grazing through M2B Grazing Alliance

- Miles of streamside forest buffers planted
- Acres of cropland using cover cropping to fix nitrogen and prevent erosion
- Number of farms adopting no-till or low-till practices
- Acres of silvopasture established
- Number of farmers trained in sustainable practices through peer mentoring, workshops, and technical assistance
- Reduction in nitrogen runoff from precision application and cover cropping

Hampton Roads Climate Action Plan
TRANSPORTATION



Transportation is one of the largest sources of regional greenhouse gas emissions (35%) - but also one of our biggest opportunities for improvement.

BREAKDOWN OF TRANSPORTATION EMISSIONS

72% **Light Duty Vehicles**

CO_2

11% **Rail, Off-road, Marine**

10% **Heavy Duty Vehicles**

5% **Aircraft**

2% **Recreational Boats**

Over 12,000 registered **electric vehicles** in Hampton Roads

~1 public charger for every 22 registered **electric vehicles** in Hampton Roads

KEY FINDINGS

By 2050, emissions from transportation are expected to **decline 40%** due to **increased electric vehicle adoption and improved fuel efficiency**.

CO_2

VOICES HEARD AROUND THE REGION...

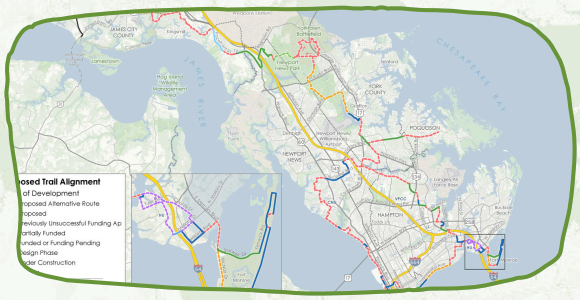
"Increased charging infrastructure for EVs would really be beneficial."

"I believe that one of the biggest things that Hampton Roads can do is reduce car dependency by improving access to public transit (including extending the Tide light rail), creating more walkable spaces, and increasing housing density."

How Hampton Roads Can Reduce Transportation Emissions

ACTION	WHAT IT MEANS	KEY BENEFITS
Increase adoption of low and zero-emissions vehicles (LEVs/ZEVs)	Build EV charging stations, convert local fleets, and expand public awareness	Lower air pollution, cleaner neighborhoods, more jobs, and reduced fuel costs
Reduce vehicle miles traveled (VMT)	Invest in buses, bike/ped networks, and transit-oriented development	Healthier lifestyles, congestion relief, and improved equity in mobility access

BUILDING UPON REGIONAL SUCCESSES



Fund the design, construction, and maintenance of identified new multi-purpose trails

Promote and expand alternative fuel programs in government fleets and public transportation

Expedite implementation of HRT's 757 Express high-frequency transit service

Transportation Sector

Transportation is commonly one of the largest sources of GHG emissions in communities due to its deep integration into daily life. Actions to reduce emissions focus on two approaches: reducing the amount of fuel needed and switching to fuels or forms of transportation that produce fewer emissions. In expanding the use of low and zero-emission vehicles, efficient technology, and use of electricity as a fuel result in reduced GHG emissions. These types of vehicles are supported by a reliable and available EV charging system, providing places to recharge throughout the region. Increasing the use of public transportation and bike/pedestrian infrastructure improvements supports the option for more trips to be made using alternative modes transportation and reduces the number of VMT and fuel needed to do so.

T1. Increase the adoption of low and zero-emission vehicles (LEV/ZEVs) by developing education, outreach, and planning materials to localities for purchasing and maintaining LEV/ZEVs and develop a fueling infrastructure deployment strategy

This measure aims to increase the use of low and zero-emission vehicles by expanding the availability of EV charging infrastructure, supporting government agencies and schools' fleet purchasing decisions with peer exchange resources, fleet assessment tools, and procurement practices, and providing educational materials to the community on LEV/ZEVs and incentives.

"Increased charging infrastructure for EVs would really be beneficial" – Survey response

Key Actions

- **Expand EV Charging Infrastructure**
  - Develop a regional plan to expand charging stations by identifying high-utilization sites and infrastructure gaps, prioritizing deployment along key tourist routes and in underserved areas, extending installations beyond government facilities to include commercial sites. Consider survey input for NEVI (Virginia DOT – Report Creation).
  - Expand publicly accessible EV charging network locations at government and public agency-owned facilities.
    - Coordinate with VDOT in counties or at park and ride lots.
    - Partner with EV charger network providers to install and maintain the network through cost-sharing programs.

Gloucester County is looking forward to adding new EV charging stations by seeking grant opportunities and encouraging developers to include it in their plans. Source: Gloucester County, VA Sierra Club 2025 Presentation.

- Increase regional EV-Readiness and private property electric vehicle supply equipment (EVSE) installations:
  - Participate in the Charging Smart program to enhance EV readiness. Participation includes establishing policies and procedures for deploying EV charging infrastructure. This is modeled after the SolSmart program, where local governments and PDCs can choose to implement the program.
  - Create incentive programs and outreach initiatives to support installation and permitting. Consider expedited permitting, tax incentives, or density bonuses to developers who voluntarily incorporate EV charging stations.
  - Implement EV charging requirements for multifamily and commercial developments by using examples from international and California building codes for EV-ready standards.
- As the NEVI program expands, advocate for the inclusion of more highways in the VDOT Alternative Fuel Corridor identified in the EV infrastructure deployment plan.
- Develop an Intergovernmental Support Agreement with DoD to collaborate on charging infrastructure to support military EV charging.

- **Increase ZEV adoption in government agency and school fleets**
  - Facilitate peer-to-peer information sharing between local governments to share best practices, use common purchasing tools, and be up-to-date on the state of ZEV technology.
    - Promote alternative fuels successes like Newport News propane school bus conversions and Chesapeake's Renewable Natural Gas Fueling station which is the largest in the region.
  - Partner with Virginia Clean Cities to hold Green Fleet Expos, similar to Norfolk's event in 2025.
  - Evaluate and recommend ZEV-focused fleet assessment tools, like the DOE Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool, based on input from early adopters in Hampton Roads.
  - Develop ZEV procurement practices:
    - Integrate ZEVs into government contract networks.
    - Coordinate bulk procurement of ZEVs across the region's localities.
  - Develop ZEV infrastructure plans:
    - Evaluate high-emission vehicle routes and vehicles that serve and pass through communities with high health risks to prioritize locality trucks (trash/public works/buses) alternative fuel conversion.
    - Develop templates/case studies for siting ZEV fueling infrastructure located to serve both fleet and public use.
    - Develop a concept for shared EV charging infrastructure for fleets across Hampton Roads.
    - Identify city-owned properties and garages that can be used as dual charging opportunities for fleets and the public. Examples include York County, James City County, Newport News, and Norfolk.

Municipal Renewable Natural Gas Fleets

The Cities of Chesapeake and Newport News are making great strides in converting municipal fleets:

- Chesapeake was the first city in Virginia to have a municipal renewable natural gas fleet
- More than half of Newport News Public Schools' bus fleet is fueled by propane

Newport News, VA improved their city electric vehicles by adding 253 electric vehicles, and the city is on track to avoid 350,000 gallons of gasoline and 3,000 metric tons of greenhouse gas emissions from FY22 through FY26. Source: Newport News, CA Sierra Club Roundtable.

  - Actively pursue federal funding opportunities such as they arise and where applicable.
  - Work with hiring managers to include EV maintenance skills for fleet jobs and offer training for existing staff.
- **Provide educational materials to support ZEV adoption**
  - Increase acceptance of EVs by demystifying maintenance and highlighting fuel and cost savings.
    - Create a regional EV Information Hub with details on federal and local incentives for residents and businesses, information on the availability of publicly accessible charging stations, and a GIS display with charging locations.
    - Organize community education and outreach events featuring technology demonstrations and EV maintenance information.
    - Provide a repository for case studies to highlight localities and organizations at various stages of ZEV adoption.
    - Partner with Dominion and/or VA Clean Cities to host a workshop on EV utility services.
  - Advocate for incentives
    - Promote Dominion's program to assist with L2 charging for residents and businesses and provide upfront subsidies to lower cost barriers.
    - Address the annual highway fee for EVs and explore local incentives to offset costs for low-to-moderate income (LMI) residents.
  - Develop training programs at trade schools for EV maintenance.
    - Tidewater Community College offers an Online Electric Vehicle Fundamentals credential program.

Zero-Emission Vehicles

The City of Norfolk offers a dedicated website to help residents learn about electric vehicles (EVs). It provides essential information on:

- What EVs are
- Where to find charging stations
- Norfolk's EV Charging Plan

By offering clear and user-friendly resources, Norfolk is making EVs more approachable for the wider community and helping residents feel more confident about adopting electric transportation.

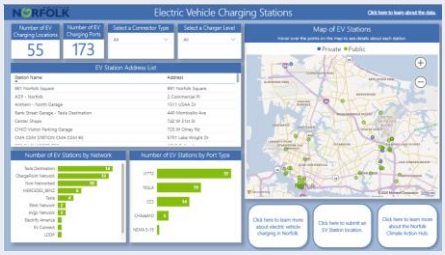


Image of the Electric Vehicle Charging Station Map. Source: City of Norfolk

EVs and Home Charging Costs

- Typical upfront cost: $40,000 plus $1,200 for home-charger installation
- Typical first year operating costs: $7,200
- Estimated lifetime savings over 15 years: $14,700 vs. a comparable gasoline vehicle.

These savings help offset the higher upfront price, with a typical payback period of approximately 5–10 years, depending on annual mileage, electricity rates, charging access, and available incentives. See Appendix E for more information.

Key Implementers

- **Utilities.** Engaging with local electric and gas service providers (e.g., Dominion Energy, Columbia Natural Gas) for the MSA will be important to ensure electrical grid stability and reliability to support increased electric loads from electrification; to support infrastructure development for hydrogen fueling stations; and to support use and blending of renewable natural gas.
- **Regional planning organizations.** Regional planning organizations, such as HRPDC/HRTPO, can coordinate development and implementation of EVSE network and ZEV fueling plans.
- **State and local government organizations.** Organizations such as NCDOT and VDOT can use federal funding to build EV charging networks and implement communitywide buying co-ops for EVs for public and private fleets as well as personal vehicles.
- **Private sector partners.** Private businesses and landowners can partner in adopting ZEVs and building publicly accessible charging stations on their properties.

Metrics for Tracking Progress

- Number of new DC fast chargers installed
- Number of ZEVs purchased for public fleets; percent of fleets that are ZEV
- Number of localities with EV/EV-ready building requirements
- Number of localities with streamlined EVSE permitting processes
- Number of localities or agencies with ZEV transition plans integrated in capital improvement programs
- Percent of new vehicles sales that are EVs

T2. Reduce vehicle miles traveled and support alternative modes of transportation through bike/pedestrian infrastructure investments

Through a range of actions, this measure aims to build upon an existing foundation of transit services and bike/pedestrian facilities in Hampton Roads, expanding infrastructure and services to improve connections, safety, and integration with existing resources. Additional actions focus on operations, supporting an increase in the number of public transit operators and policies and technologies that could reduce the need for fleet vehicle travel.

"I believe that one of the biggest things that Hampton Roads can do is reduce car dependency by improving access to public transit (including extending the Tide light rail), creating more walkable spaces, and increasing housing density." – Survey response

Key Actions

- **Support efficient implementation of transit services throughout the region**
  - Expedite implementation of 757 Express high-frequency transit service for HRT's regional backbone routes by supporting HRT's System Optimization Plan (SOP). The SOP has a goal of how the agency can put its limited resources to best use by reducing low-ridership local bus service and reinvesting those savings in routes with high ridership demand. (There has been a 35%-47% increase in ridership since the current three routes were implemented).
    - Identify and provide recruitment and resource needs to increase the number of public transit operators.
    - Expand high-capacity transit coverage and service hours.
  - Support building and improving major roads in ways that help buses move faster and more reliably, like giving them priority at traffic signals or special lanes to skip traffic.
    - Conduct feasibility studies to expand rapid bus service backbone to Williamsburg Area Transit Authority (WATA) and Suffolk Transit.

Base Express

Hampton Roads Transit (HRT) provides free rides within Naval Station Norfolk.

- Connects key locations on the base
- Two routes provide consistent service (15-30 min intervals)
- A shuttle tracker offers precise pick-up times.

Map of the Blue and Gold Bus Routes on Naval Station Norfolk. Source: HRT

- Support expansion of On-Demand microtransit where fixed route transit service is limited or infeasible.
  - Develop policies to strengthen microtransit, like Chesapeake and HRT's incentive program for a Microtransit Zone pilot. This will allow riders microtransit opportunities to connect to a larger fixed bus route.
- Conduct walkability assessments around bus stops. Start with 757express.
- Encourage localities to construct sidewalks and provide infrastructure for passenger amenities at bus stops to improve transit service accessibility.
- Encourage businesses/universities to adopt/promote use of bus stops and passenger amenities.
- Promote existing rideshare programs, transit, and alternative modes of transportation use through HRT's GoCommute, employee incentive programs, pre-tax offerings, and discounts.
- Coordinate with VDOT, HRT, and localities to partner with large commercial facilities to host Park and Ride lots.
  - Utilize HRT's How to Take Transit to the Tides resource.
- Expand transit, options for DoD installations, such as HRT's Base Express at Naval Station Norfolk.

  Promote passenger rail service, especially to Washington, DC., Petersburg and Richmond.

HRT added 12 new buses to 757 Express in November 2023. Source: HRT

- Expand high-capacity transit coverage and service hours.
- Promote and expand 'free ride transit days' to tie in with holidays, bike, or safety months.
  - HRT already has Ride HRT for free on Transit Equity Day, Earth Day, Juneteenth, and during large public events.
- Promote the Student Freedom Pass available through HRT to teens ages 13-17, offering unlimited free rides on HRT's bus, ferry, and light rail services.
  - Advocate for WATA and Suffolk Transit to provide a similar program.

"Be salutogenic - aim to reimagine reality, not just fix problems! Create a vision for what our landscape can look like by design and default." – Survey response

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- **Research and support updates to land use and zoning policies**
  - Establish on-going dialogue between municipalities and transit agencies serving Hampton Roads to advocate for transit supportive land uses and policies.
    - Develop a series of workshops on the design and impact of transit-oriented development.
    - Implement Complete Street Policies, create a safe and consistent transportation network for all users.
    - Review HRTPO's Long Range Transportation Plan (LRTP) growth scenarios.
    - Support higher density development that encourages high-frequency transit service.
    - Develop a tool kit for localities to support transit-oriented development.

- **Consider government/agency operational changes**
  - Convert all water meters to remote reporting to eliminate miles driven for meter reading.
  - Implement policies to reduce commuting by promoting telework options.
  - Consider adopting no idling policies for locality fleets when appropriate.

" I often travel to my local exercise gym, library, & grocery by driving because there are no bike lanes. It's very dangerous with no shoulder on the two-lane road. I would much rather ride my bike or walk to these often-visited places." – Survey response

- **Enhance infrastructure to promote micromobility, cycling, and pedestrian-friendly transportation options**
  - Improve rural roadways for safer biking.
  - Set goals for additional sidewalk infrastructure, provide funding, and encourage safety to counter right of way concerns.
  - Fund the design, construction, and maintenance of 62,832 feet (11.9 miles) of identified new multipurpose trails, including the Trail 757/Virginia Capital Trail Extension, South Hampton Roads Trail, and the Elizabeth River Trail.
  - Use Chesapeake's Trails and Connectivity Plan as a model for other localities to provide access to alternative transportation networks. Provide information such as bike parking locations and access points for the regional shared use trails.
  - Develop recommendations for scooter/bikeshare expansion by exploring Norfolk's Scooter and Bike Rental Dashboard to better understand micromobility patterns and usage over time.
  - Increase biking opportunities.
    - Establish biking to school programs.
    - Promote HRT's bike month in May.
    - Gather data for safe biking routes using handlebar sensors.
    - Consider reduced speeds in highly biked areas.
    - Increase the number of dedicated bike lanes. When re-striping roadways, evaluate road width to add in bike lanes where feasible. Localities can coordinate between departments when re-paving is planned to identify needs for active transportation. Chesapeake and Virginia Beach are good examples of this coordination.
    - Use HRT's GoCommute tool to identify commuting opportunities via biking or walking.
    - Promote using the bikeshare program(s) for public events like Harborfest.
    - Share findings from the VA Beach working group on e-bike solutions.

The Elizabeth River Trail

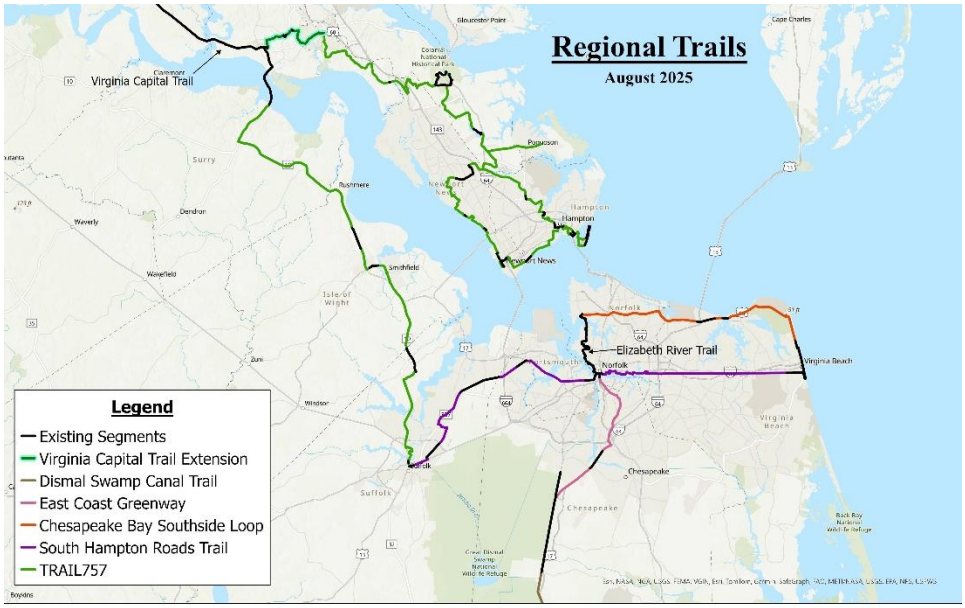
This urban trail is a scenic route designed to connect walkers and bikers to Norfolk's waterfront, local universities, and historic attractions.

Across **10.5 miles**, the trail encourages active transportation and community connection.

Community members biking along the Elizabeth River Trail. Source: Elizabeth River Trail Foundation

Key Implementers

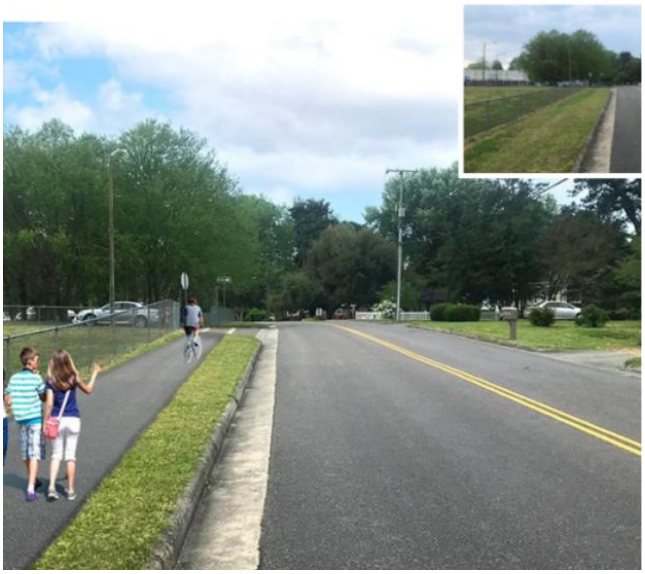
- **State and local government agencies.** Agencies such as VDOT and NCDOT and local governments can implement programs. Virginia's DRPT can provide funding, studies, and reports to support program implementation.
- **HRTPO.** As a regional planning organization, HRTPO works to align multimodal transportation infrastructure with overarching transportation goals in the region.
- **Community groups and nonprofit organizations.** Community-based organizations can provide insight into the transportation patterns and needs of the community when developing multimodal infrastructure. In some cases, projects can be led by a dedicated local organization; for example, the Elizabeth River Trail Foundation is responsible for planning, programming, and advocating for the Elizabeth River Trail.
- **Private sector partners.** Private sector partners, such as property owners, developers, and businesses play a key role in development decisions and design that affect the viability and feasibility of using alternatives to driving.



Regional trails planned for the Hampton Roads region. Several sections of these trails are already funded. Source: HRTPO

Metrics for Tracking Progress

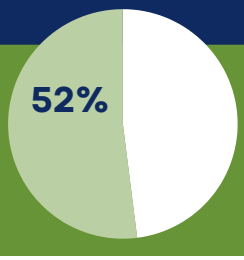
- Percentage of water meters with remote reporting
- Amount of geographic area served bikeshare programs
- Number of bikeshare program registered users, annual rides, and trip length
- Completed project count and length of:
  - Shared use paths
  - Sidewalks
  - Bike lanes
  - Paved shoulder
  - Paved unpaved road
  - Other bike/pedestrian facilities
  - Bike/pedestrian design features
- VMT per capita
- Additional miles of bicycle or pedestrian lanes added
- Bus ridership counts, including a breakout for BRT
- Number of vehicle miles reduced due to water meter remote reporting



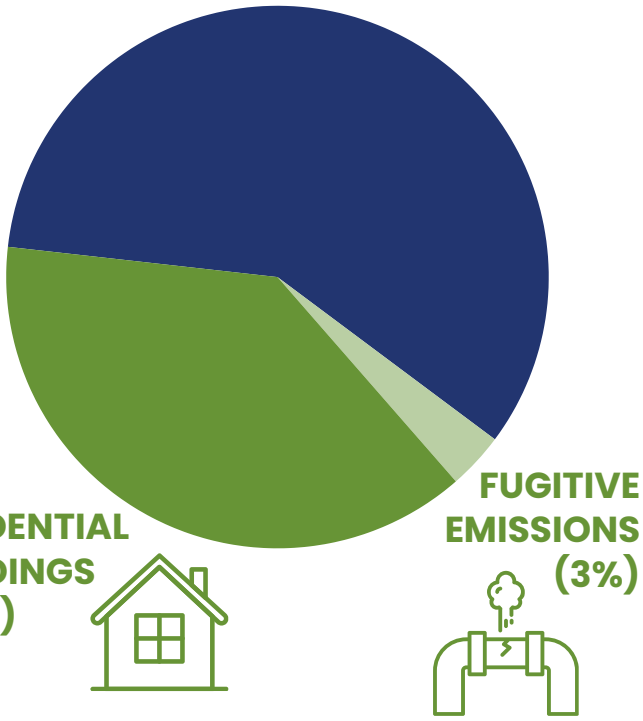
Gloucester County, VA is enhancing their trails and multimodal paths by expanding and repairing them. Source: Gloucester County, VA Sierra Club 2025 Presentation.

Hampton Roads Climate Action Plan
BUILDINGS

Buildings are the largest source of regional greenhouse gas emissions (52%)



COMMERCIAL & INDUSTRIAL BUILDINGS (52%)



How do buildings emit greenhouse gases?

STATIONARY COMBUSTION: burning natural gas for heating or cooking

ELECTRICITY USE: generating power for lights, appliances, HVAC

FUGITIVE EMISSIONS: leaks and inefficiencies in equipment

REFRIGERANTS: hydrofluorocarbons (HFCs) from cooling systems

VOICES HEARD AROUND THE REGION...

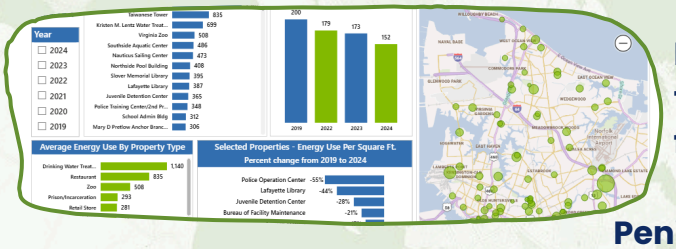
"Rooftop solar on ALL public buildings..."

"... [H]ave access to a certified list of reputable companies that can do solar panels or new windows or even new insulation in a house..."

How Hampton Roads Can Reduce Emissions From Buildings

ACTION	WHAT IT MEANS	KEY BENEFITS
Lead by Example in Public Buildings	Upgrade schools and municipal buildings for energy efficiency, electrification, and solar power	Lower costs for taxpayers, reduced emissions, improved learning environments
Weatherize & Electrify Homes	Help residents lower bills and emissions through weatherization, energy audits, and efficient electric appliances	Reduces household energy costs, improves comfort, and supports energy equity for all income levels
Improve Commercial & Industrial Efficiency	Encourage businesses to adopt high-performance building designs and above-code efficiency standards	Cuts operating costs, boosts competitiveness, creates clean-energy jobs, and improves local air quality

BUILDING UPON REGIONAL SUCCESSES



Norfolk & Virginia Beach have energy tracking software on public buildings to help find opportunities to reduce costs

Peninsula localities reward green businesses with the Clean Business Forum Awards

Solar on schools is growing in Hampton Roads

Localities partner with Project Homes and Community Housing Partners to provide energy audits and home weatherization tools

COMMUNITY HOUSING PARTNERS

project:HOMES
Improving Lives by Improving Homes

Buildings Sector

Buildings and the energy they use are one of the largest sources of GHG emissions in communities, including residential, commercial, governmental, and industrial buildings. Reducing GHG emissions in this sector includes activities that make existing buildings more energy efficient through upgrades such as weatherization and electrification, encouragement of newly constructed buildings to be designed and built above current code requirements so that they use less energy, and technical assistance for government and school buildings to achieve net zero operations.

B1. Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for local government and school buildings

Starting with a Lead by Example approach, this measure focuses on reducing GHG emissions and energy use in government and school buildings, reducing their ongoing energy use and costs, and fostering an information-sharing environment supported by tools, case studies, implementation guidance, and peer and industry networks.

Key Actions

- **Encourage localities to lead by example in facility efficiency and electrification**
  - Adopt local requirements for new construction and major renovations of government buildings.
    - Meet Virginia's High-Performance Buildings Act requirements to ensure new and renovated buildings meet efficiency requirements.
    - Consider strengthening the High-Performance Buildings Act.
    - Ensure all new government buildings meet Leadership in Energy and Environmental Design (LEED) standards, following the successful implementations in Hampton and York County.
    - Consider adopting sustainable design standards as exemplified by the City of Richmond with specific requirements for horizontal and vertical public and private projects.
  - Set locality-specific energy consumption and reduction goals and develop building energy performance standards
    - Follow Department of Energy's Better Buildings Challenge
    - Track energy usage through software like EnergyCAP to help identify energy demands, address maintenance issues, reduce costs, pay bills, and achieve goals. Norfolk leads by example with their online data portal and recently released a new energy data dashboard.

LEEDing by Example

The Chesapeake Bay Foundation Brock Environmental Center is a model for green and resilient building globally. It was designed to follow LEED platinum and Living Building™ Standards.

The Living Building certification means that the building has a "**net zero**" impact on the environment after being operational for a year.

Brock Environmental Center. Source: Chesapeake Bay Foundation

  - Consider energy-saving performance contracting options.
  - Participate in energy audit program using the Hampton city facilities' audits as a guide.
  - Promote all-electric new construction in municipal buildings.
  - Require energy benchmarking for buildings over 50,000 sq ft.
  - Use analytics and monitoring-based building commissioning to continuously improve building performance over time.
- Install LED streetlights along public rights-of-way.
  - Consult with Dominion to identify locations and options for replacement.
  - Create dashboard to track LED installations.
  - Share best practices to ensure lighting isn't harmful to migrating birds and address community concerns, like adding a shield.
  - Work through Virginia Energy Purchasing Governmental Association (VEPGA) to engage Dominion on color temperature, advancements in lighting technology and environmental best practices.

York County, VA is reducing energy consumption by adding LED light fixtures to public spaces such as streets and athletic fields. Source: York County, VA Peninsula Area Climate Solutions Roundtable Presentation.

- Install LEDs in government buildings.
- Evaluate public buildings and parking lots for solar installation including prioritizing installations that do not trigger more expensive grid upgrades.

"Rooftop solar on ALL public buildings..." – Survey response

  - Encourage localities, housing authorities, and school districts to participate in VEPGA.
  - Establish a revolving green fund for energy efficiency projects, leveraging resources like DOE's Loan Program Office and Norfolk's $300K Green Fund.
  - Partner with local utilities to offer energy efficiency rebates.
  - Model Virginia Beach's approach to use a third party to conduct energy bill audits for free, owing only 25-30% of their findings.
  - Work with Virginia Association of Counties (VACo) to understand the Virginia Department of Energy's Energy Savings Performance Contracting (ESPC) to "use guaranteed savings from the maintenance and operations budget for utilities as capital to make needed upgrades to a facility, financed over a specified period of time".
- **Improve information sharing about energy efficiency programs and case studies across the localities**
  - Develop forum/committee for local governments to convene and share knowledge.
  - Create a regional communication strategy to inform local governments about available resources and engage the public to combat misinformation.
  - Develop a list-serve to foster ease of communication and information sharing among local staff.

- Develop cost-savings estimates based on energy tracking and models to better communicate the life cycle costs of sustainable investments.
- Compile cost information for practices and provide implementation guidance.
- Host a clearinghouse for case studies to be used as informational tools and best practices across localities.
  - Create a template for case studies to be shared across localities that highlights successes, challenges, cost-savings, life-cycle costs, and energy savings to be used to advocate for funding, convey lessons learned, communicate critical needs, and showcase successful projects.
  - Evaluate case studies from the annual award program for government projects hosted by the Virginia Energy Efficiency Council.

A render of proposed sustainable buildings, including a new government center with a potential library addition and a new general services building in James City County, VA. Source: JCC Climate Solutions Roundtable

- Develop an inventory of grants and loans available that fund government building upgrades and consider developing Intergovernmental Support Agreements (IGSAs) with local military installations for EV charging infrastructure, LED streetlights, and LED lights. Identify requirements, upfront costs, return on investments, program challenges. (See list compiled by HRPDC).
- Provide training for locality staff to understand their energy footprint and how they can help, offer sustainability lunch and learns, provide engaging challenges like "Watts Going Down Norfolk", create a joint energy team across departments.
- Consider involvement in the Virginia Energy Efficiency Council and the Southeast Sustainability Directors Network to engage with likeminded partners and share best practices, resources, and opportunities.

Key Implementers

- **State governments and local government agencies**. Virginia's DHCD, DEQ, SCC, along with NCDEQ, NCUC, and other state agencies can support implementation. Relevant local government organizations (such as the Department of Public Works) in the Virginia Beach and Norfolk areas can provide support and share best practices when implementing this measure.
- **Regional Planning Organizations (RPOs).** These entities can create continuity of work between state and local governments and support technical assistance.
- **Dominion Energy.** The major electric utility provider for the MSA provides energy efficiency programs for residential customers.
- **Contractors and Equipment/energy service providers.** Private sector partners such as contractors and equipment manufacturers service providers can partner to provide the skills and equipment needed to retrofit buildings.

Metrics for Tracking Progress

- Number of LEED-certified local government and school buildings
- Number of schools and local government buildings that participated in incentive programs for building energy efficiency or electrification
- Metrics from building energy performance standard, including energy and emissions from participating facilities
- Number of heat pumps installed
- Number of efficiency gas and electric HVAC systems installed
- Number of projects that paired building upgrades with EV infrastructure installation or onsite solar

B2. Reduce energy consumption and increase building efficiency through programs to support, incentivize, and install weatherization and electrification measures in residential buildings

This measure aims to connect financial, educational, and technical resources with eligible properties, owners, and property managers to support energy upgrades and energy efficient appliances in residential properties. Specific resources for multi-family, public housing, and other lower income properties are identified, as these property types can require specialized resources and support due to their ownership and investment structures, property size, and having to coordinate with many residents for building access.

"... [W]ork on weatherization and efficiency of homes, especially low income." – Survey response

Key Actions

- **Support and promote residential weatherization programs and energy audits**
  - Work directly with Project Homes and Community Housing Partners.
  - Advocate for state and federal funding along with utility sponsors to continue to support weatherization and energy efficiency programs.
  - Promote and utilize the new Virginia Energy Connect hub, a one-stop shop for residents and contractors to find information on incentives and programs for energy efficiency in their homes and businesses.
  - Work with locality departments of Social Services, Economic Development, and Community Development to provide referrals and drive efforts to urban centers.
    - Identify multi-family housing partners willing to participate in weatherization and energy programs.
    - Work with Dominion and their Property Management department to connect with multi-family property owners.
    - Partner with training programs (ex. Community Housing Partners Research and Training Center) to encourage earning certification credentials.
    - Recognize that not all localities will have the resources or staff to promote these programs and work towards identifying non-profits that can assist them.

"... [H]ave access to a certified list of reputable companies that can do solar panels or new windows or even new insulation in a house..." – Survey response

- **Promote voluntary residential upgrades to reduce energy consumption**
  - Provide outreach and education on opportunities that are available to homeowners, like installing insulation, sealing holes, duct sealing, replacing heat pumps or air handlers, etc.
  - Work with Dominion and partners (e.g., CHP, Project Homes, Virginia Municipal League) to offer and conduct free energy home audits.
  - Create cost/benefit comparisons between existing gas heating and cooling and electric or hybrid heating and cooling.

- Develop an information hub on federal tax incentives and utility rebate programs for building efficiency, electrification, and clean energy technologies and available state programs and how to participate in them.
- Leverage VA and NC Home Electrification and Appliance Rebates (HEAR) programs to advance energy efficiency and building electrification in the region.
- Promote Dominion's rewards, rebates, and energy efficiency programs for homeowners and target local businesses of all sizes to generate interest in building services and equipment settings programs and specialty efficiency solutions in agriculture, data centers, hotels, and the healthcare industry.
- Help support or promote micro-grants.
- Partner with local schools, non-profits, or libraries to create educational programs, toolkits, and give aways.
  - Virginia Beach is doing this through grant funding from Energy Efficiency Conservation Block Grants and Virginia Natural Gas Foundation.
  - Purchase 'kill-a-watt' kits as giveaways for public education to measure and record the amount of electricity consumed to compare across plug, lighting, and mechanical electricity.
  - Place energy savings kits and giveaways in public libraries, users can check a kit out for do-it-yourself home assessments.
- **Identify gaps in buildings codes, ordinances, and permitting processes that disincentivize decarbonization in residential buildings**
- **Research philanthropic, state, and federal community zero-interest short term loans to retrofit and upgrade public housing**

Virginia Beach Green Savers

Green Savers, established in 2023 by Virginia Beach Public Library (VBPL), helps residents conserve energy and reduce costs. Toolkits are loaned out to assess home energy and water usage.

TCC/City Joint-Use Library. Source: VBPL

Key Implementers

- **State governments and local government agencies.** Virginia's DHCD, DEQ, SCC, along with NCDEQ, NCUC, and other state agencies can support implementation.
- **Local governments.** They will play a key role in disseminating information and providing educational resources.
- **Non-profit organizations.** These organizations can meet with community members and promote increased education on opportunities to improve energy efficiency of homes and residences.
- **Dominion Energy.** The major electric utility provider for the MSA, Dominion Energy provides energy efficiency programs for residential customers.
- **Homeowners, building managers, and renters.** These groups are ultimately responsible for conducting home improvement projects.
- **Contractors and equipment/energy service providers**. Private sector partners such as contractors and equipment manufacturers service providers can partner to provide the skills and equipment needed to retrofit buildings.

Heat Pump HVAC System Costs

- Typical upfront cost: $10,000–$17,000 before incentives
- Incentives: up to $8,000 in federal rebates may be available (HEAR)
- Estimated lifetime savings over 15 years: $5,400 - $24,200 compared to a gas furnace/central AC and electric resistance/central AC system

These savings help offset the higher upfront price, with a typical payback period of approximately 5–10 years, for households transitioning from electric-resistance systems. See Appendix E for more information.

Metrics for Tracking Progress

- Number of residential buildings that participate in incentive programs and number of types of equipment or retrofit undertaken (e.g., weatherization or heat pump installation)
- Energy use change and GHG emissions improvements from tracked projects
- Number of residential homes or units in low-income and disadvantaged communities (LIDACs) that receive energy efficiency and/or electrification retrofits or upgrades
- Number of participants in any voluntary benchmarking programs
- Number of outreach events and technical assistance materials developed and shared
- Overall energy consumption and change in GHG emissions from the residential buildings sector in the region

B3. For commercial and industrial buildings, increase energy efficiency through financial incentives and educational outreach programs and strongly encourage the design, building, and operation of buildings above current required code

This measure combines identification of funding and financing sources, incentives, education, and recognition programs to support increased energy efficiency in C&I buildings.

Key Actions

- **Identify funding to support programs for energy efficiency improvements for C&I buildings**
  - Low- to no-cost energy audits for small businesses.
  - Promote/research on-bill financing and tax incentives.
  - Encourage participation in Commercial Property Assessed Clean Energy (C-PACE) program. Work with lenders and localities to find common ground and identify risks and terms that work for all parties. Launch a working group to find lenders willing to participate.

"Use Green Business Alliance … to get businesses to capture low-hanging fruit on energy, like turning heat and A/C to reasonable values rather than over air-conditioning in the summer" – Survey response

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- **Conduct outreach on decreasing energy consumption in C&I buildings**
  - Replicate North Carolina's High Performance Building program (HiPerB), which is designed to showcase the energy performance of commercial buildings in the state. This program focuses on new construction and major renovations, comparing measured post-occupancy energy data and costs to baseline and design models.
  - Partner with community-based organizations, local and regional civic leagues, business chambers, and utilities to educate building owners, including non-profits, places of worship, and small businesses on best practices for decarbonization, and facilitate connections with utility providers to identify resources and available rebate and incentive programs.

- Identify locations for Resilience Hubs to learn how to address impacts from climate change. Portsmouth is leading by example through their resilience hub at a local church with the help of community leaders and non-profits. The site can be a place to gather to learn about issues and solutions (like Cool Down P-Town) and can have demonstration projects that residents can implement like tree planting, solar panels, EV charging stations, or possibly a micro-grid.
- Facilitate connections between C&I building energy managers or sustainability staff to support knowledge sharing on tangible ways to decrease energy consumption.

- **Encourage and incentivize voluntary reporting of energy consumption and offer recognition programs for high performing businesses**
  - Create energy tracking reporting program for commercial and large multi-family or mixed-use buildings.
  - VA DEQ manages the Virginia Environmental Excellence Program (VEEP) Sustainability Partners track to encourage large businesses to make effective sustainability changes.
  - Model locality programs like York County, James City County, Newport News, and Hampton who all have clean business forum awards.
  - Publicize high performing buildings and recognition programs (LEED certified, Energy STAR, etc.) to ensure that people are aware of the energy efficiency updates that can be made and motivate buildings that are already high performing to continue their efforts.
  - Public tours of high performing buildings to help construction companies, building owners, and other entities to envision future energy efficiency changes
  - Encourage residential and commercial building owners to make upgrades to their buildings through challenges, outreach, and education activities.
- **Advocate for energy efficient building designs**
  - Investigate options available to encourage above code development through the permitting process.
  - Engage with state lawmakers and regulatory agencies to update building code.
  - Provide outreach on optimization of a building's energy performance through construction modeling.
    - Focus on passive design strategies such as site orientation, window placement, and materials. Orienting the building to face east-west can maximize natural lighting and minimize glare, while a north-facing window can offer efficient natural lighting with less heat gain.
    - Utilize energy-efficient windows with low-emissivity coatings and high-performance materials like warm edge spacers to reduce heat transfer. This will aid in solar optimization too.

Clean Business Forum Awards

By adopting green initiatives, a business can be recognized by the Clean Business Forum Awards. James City County, York County, Hampton, and Newport News cosponsor the award with the Clean County Commission.

Bricks & Minifigs was a 2025 Second Quarter Recipient of the Clean Business Forum Award. Source: James City County

"[W]ould love to see us join Strong Towns or similar to make overall planning and design a part of a comprehensive overhaul of our area's climate plan. We need to design for smarter living ..." – Survey response

Key Implementers

- **State governments and local government agencies.** Virginia's DHCD, DEQ, SCC, along with NCDEQ, NCUC, and other state agencies can support implementation. Relevant local government organizations (such as the Department of Public Works) in the Virginia Beach and Norfolk areas can provide support and share best practices when implementing this measure.
- **Dominion Energy.** The major electric utility provider for the MSA, Dominion Energy provides energy-efficiency programs for C&I customers.
- **Building owners and energy managers.** These groups are ultimately responsible for conducting home improvement projects.
- **Contractors and equipment/energy service providers.** Private sector partners such as contractors, equipment manufacturers, and service providers can partner to provide the skills and equipment needed to retrofit buildings.
- **Non-profit organizations.** These organizations can meet with community members and promote increased education on opportunities to improve energy efficiency of homes and residences.
- **Homeowners, building managers, and renters.** These groups are ultimately responsible for conducting home improvement projects.
- **Contractors and equipment/energy service providers.** Private sector partners such as contractors, equipment manufacturers, and service providers can partner to provide the skills and equipment needed to retrofit buildings.

Metrics for Tracking Progress

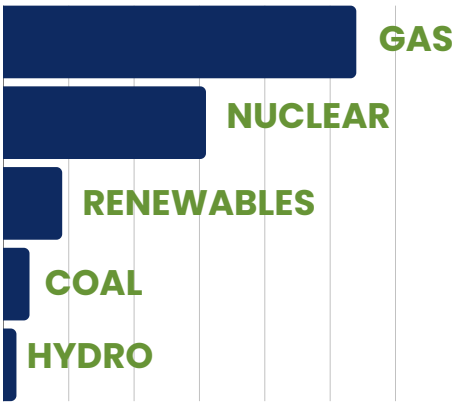
- Number of residential buildings that participate in incentive programs and number of types of equipment or retrofit undertaken (e.g., weatherization or heat pump installation)
- Energy use change and GHG emissions improvements from tracked projects
- Number of participants in any voluntary benchmarking programs
- Number of outreach events and technical assistance materials developed and shared
- Overall energy consumption and change in GHG emissions from the C&I buildings sector in the region
- Number of new buildings that participate in incentive programs and certification level achieve (e.g., LEED or others)
- Number of buildings that are all-electric, net zero, or meet passive house standards
- Number of participants in any ongoing voluntary benchmarking programs
- Number of outreach events and technical assistance materials developed and shared

Hampton Roads Climate Action Plan
ENERGY SUPPLY

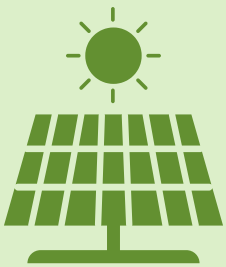
Hampton Roads can meet its **energy demand** through **traditional energy sources** like burning fossil fuels and **clean energy sources** like solar, wind, and nuclear.

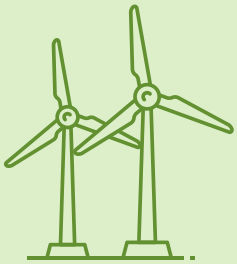
Power used in the region comes from Virginia's power grid, a mix of **gas-generated** (54%), **nuclear** (31%)**, renewables** (9%), **coal** (4%), **hydroelectric and petroleum** (2%).

However, **regional power generation** is primarily from the **Surry nuclear plant** in addition to **3 gas, 5 oil**, & **31 solar plants.**



Clean energy sources include use of **solar panels**, **wind turbines**, or **nuclear fission**. Power is generated without emitting greenhouse gases. **55%** of **electricity** in Virginia comes from **clean power.**





VOICES HEARD AROUND THE REGION...

"Need to accelerate our conversion to renewable energy system, like solar and wind"

"Governmental support for renewable energy production needs to be maintained and more created"

How Hampton Roads Can Reduce Emissions from Energy Supply

ACTION	WHAT IT MEANS	KEY BENEFITS
Accelerate Solar Energy Adoption	Expand solar programs, make permitting faster, and launch a regional Solar Hub to connect residents, businesses, and installers	Lowers energy bills, boosts local jobs, and reduces carbon emissions
Support Grid-Scale Clean Energy	Partner with utilities to develop large-scale clean energy projects (like offshore wind) and strengthen the power grid	Increases reliability, creates economic growth, and supports regional resilience

BUILDING UPON REGIONAL SUCCESSES

Many communities are members of SolSmart, an initiative making it easier and more affordable to go solar.

The Coastal Virginia Offshore Wind project will generate enough energy to power up to 660,000 homes in the region.

Students in Newport News learned how to build a solar oven, learning about solar energy technology and careers.

Energy Sector

With growing technology and manufacturing advances, there are more opportunities to generate renewable and clean energy. Installing solar panels distributed across rooftops and parking lots on public and private properties can reduce the amount of energy needed from the grid, freeing up that energy to be used elsewhere. Grid-scale facilities and investments in grid resiliency reduce the overall emissions of energy supply and offer the potential of clean and renewable energy benefits to properties not well suited for their own onsite installations.

E1. Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub

A number of program models, tools, and state resources exist to reduce barriers and challenges to installing solar energy systems. This measure identifies specific resources and programs that could be replicated or expanded in Hampton Roads.

Key Actions

- **Enhance solar energy on government, residential, and commercial buildings**
  - Monitor federal program status and encourage localities to participate in Virginia Department of Energy's Solar for All program and North Carolina's Solar for All program, EnergizeNC when they become available again.
  - Streamline the permitting process across localities, consider using SolarAPP+ for permitting.
  - Encourage localities to participate in the SolSmart recognition program to allow for centralized permitting, to help develop rapid permitting processes, and to continue to promote and make solar easier for residents and business owners.
- **Develop a Solar Hub website**
  - With help from HRPDC staff, coordinate with the Local Energy Alliance Program (LEAP) to develop a regional solar energy hub
  - Use the Northern Virginia Regional Commission's (NVRC) Solarize NoVA, as a model to participate in the Solarize program through LEAP. This will allow the region to vet solar installers and de-mystify the challenges of residential solar installation.
  - Continue to encourage localities like Norfolk and other to partner with solar co-ops like Solar United Neighbors.

SolSmart

SolSmart is an initiative highlighting local governments that make it easier and more affordable to go solar by following nationwide best practices.

Norfolk's SolSmart Gold designation plaque. Source: City of Norfolk

Hampton Roads communities included in SolSmart are Norfolk, Virginia Beach, Hampton, Newport News, James City County, and York County.

- **Expand power purchase agreement options for community solar**
  - Request state assistance to support power purchase agreements (PPA) to connect more community solar projects.
  - Model a low-income solar program in the region, similar to the partnership between Dominion and Henrico County.
- **Encourage multi-benefit, community scale solar at brownfields, landfills, parking lots and reservoirs**
- **Promote grid resiliency with more distributed energy storage to reduce peaks and provide backup power in emergencies**

"Governmental support for renewable energy production needs to be maintained and more created"
– Survey response

Key Implementers

- **State and local governments.** Governments can install and procure renewable energy on or for public facilities (including schools, municipal buildings, and other public buildings), create solar ordinances and updated zoning ordinances, and develop policies and incentive programs to support renewable energy.
- **Utilities and Regional Transmission Organizations.** As providers of large-scale renewable energy and as actors in renewable energy credit markets, utilities can work with entities to negotiate for and procure renewable energy. Utilities may also work with partners to plan for integration of distributed generation and grid modernization to serve community needs.
- **Community based organizations (CBOs).** Engaging with local CBOs can help ensure that on-site solar initiatives address the specific needs and concerns of local communities. These organizations can also play a role in raising awareness and promoting community participation, (e.g., in community solar programs) or build the pipeline of trained workforce to install more distributed energy generation.
- **Private sector partners.** Collaboration with private sector entities — including solar developers, financiers, building owners, installers, and technology providers — is crucial for implementing on-site solar installations. Public-private partnerships can lead to greater funding and heightened expertise for these projects.
- **Non-profit organizations.** Nonprofits can conduct community engagement, education and outreach, capacity building, research on environmental and social impacts of clean energy projects, and/or developing and installing community renewable energy projects.

Rooftop Solar System Costs

- Typical upfront cost: $17,500–$21,000 before incentives for a 7 kW system
- Estimated lifetime savings over 25 years: $10,000 - $24,000

A 7 kW system can generate most or all of a typical home's annual electricity needs, depending on household energy use, roof orientation, and shading. Many Virginia households experience a simple payback period of approximately 10–15 years, with continued energy bill savings over the remaining life of the system.

Actual costs and savings will vary based on roof conditions, system size, equipment selected, electricity use, and available incentives from local governments, states, or utilities. See Appendix E for more information.

Metrics for Tracking Progress

- Number of solar rooftops
- Amount of distributed solar capacity installed

E2. Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency

As new opportunities in clean energy continue to develop, this measure aims to track and further adopt technologies such as the already under-development offshore wind project as well as hydrogen, propane, and nuclear resources. Supporting the development of grid-scale clean energy and enhancing grid resiliency is essential for increasing the capacity and reliability of the energy grid while promoting clean energy adoption.

Key Actions

"Need to accelerate our conversion to renewable energy system, like solar and wind" – Survey response

- **Support offshore wind development**
  - Continue to advocate regionally for offshore wind development to support Dominion and Virginia's goals for cleaner grid-scale energy sources. The Coastal Virginia Offshore Wind project is underway, once complete it will generate enough energy to power up to 660,000 homes (~3,000 MW). Regional support is valued to ensure the project continues to move forward.
  - Share information regarding the growing workforce development needs for the wind industry. One example is Centura College is offering a 48-week wind turbine technician program.
- **Explore alternative sources of energy like hydrogen, propane, and nuclear**
  - Support Virginia Tech's Clean Energy Tech Center in Newport News to advance clean energy hydrogen research and development.
  - Follow recommendations to address public perception of nuclear energy in "Enhancing Community Acceptance of Small Modular Reactors".
  - Coordinate with Virginia Nuclear Energy Consortium.
  - Conduct cost comparisons for alternative energy sources and traditional sources to make informed decisions.
- **Identify battery storage needs for alternative energy sources and identify resilience strategies to better respond during emergencies**
- **Promote the purchase of renewable energy certificates (REC) to achieve sustainability goals**

Coastal Virginia Offshore Wind

As proposed, this project will generate enough energy to power up to 660,000 homes. A win-win for increasing access to local clean energy and creating jobs, the project is expected to be complete by 2026.

Test turbine for Dominion's Coastal Virginia Offshore Wind project. Source: Virginia Mercury

Key Implementers

- **Federal, state and local governments.** Governments have control over permitting for new generation projects. For resources such as offshore wind and nuclear, federal approvals are also needed.
  - FERC. Regulates electricity and transmission of electricity in interstate commerce, the development of reliability standards and national energy infrastructure, including natural gas pipelines and more.
  - Virginia SCC. The regulatory bodies that act as a State Public Utility Commission and regulate utility rates.
- **PJM, the regional transmission organization.** PJM develops load forecasts for the region and is actively working to adapt to expected data center growth by accelerating interconnection processes, planning for new transmission infrastructure, and addressing the unique challenges posed by co-located data center generation.
- **Utilities and developers.** Electric and gas utilities (e.g., Dominion Energy, Columbia Natural Gas) and developers will be the main implementers of this measure, developing and deploying grid-scale resources in the region.

Fourth-grade classes in Newport News, VA learned about solar energy technology and careers in clean energy by building solar ovens. Source: Newport News, VA Sierra Club Roundtable.

- **Universities**. Academia and other research institutions can support the R&D and pilot project phase for emerging technologies.

Metrics for Tracking Progress

- Number of clean energy projects developed in the MSA and total capacity
- Number of pilot projects for emerging technologies for grid-scale resources
- Share of electricity consumed in the region supplied by clean energy

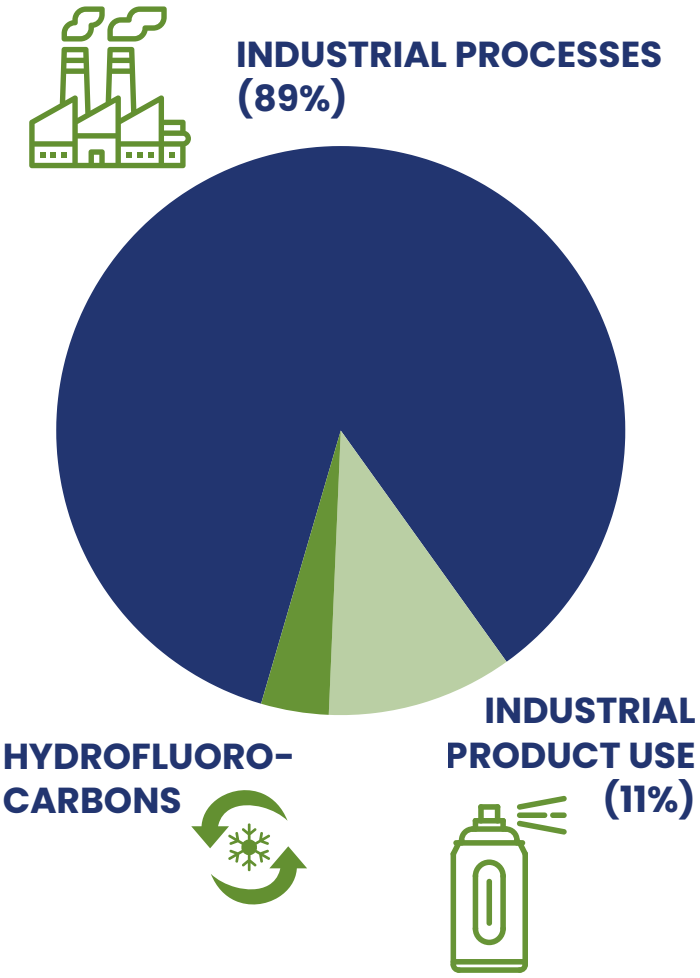
Hampton Roads Climate Action Plan
INDUSTRY

Major industries in Hampton Roads include iron and steel manufacturing and pulp and paper production.

INDUSTRIAL PROCESSES are practices that chemically or physically transform materials, like the production of paper or pharmaceuticals.

INDUSTRIAL PRODUCT USE can release greenhouse gases, like spraying aerosols or foam insulation.

HYDROFLUOROCARBONS (HFCs) are refrigerants that are potent greenhouse gases.



VOICES HEARD AROUND THE REGION...

"Gaining support from the community and industry for some of these projects will be the key to making the big changes in how we improve our environment overall."

How Hampton Roads Can Reduce Emissions From Industry

ACTION	WHAT IT MEANS	KEY BENEFITS
Reduce Industrial Process Emissions	Help industrial facilities adopt energy-efficient operations, pilot low-carbon fuels like hydrogen, and explore carbon capture technologies	Cuts greenhouse gases, saves money through efficiency, creates innovation and research jobs
Decarbonize Port Operations	Transition cargo-handling equipment, trucks, and cranes to electric or low-carbon fuels and improve logistics efficiency	Cleaner air for nearby neighborhoods, quieter operations, and global competitiveness

BUILDING UPON REGIONAL SUCCESSES

The Port of Virginia has transitioned to sourcing 100% of operations from clean energy. The Virginia Port Authority is on its way to achieving net-zero emissions for operations by 2040.

Sentara hired a Director of Sustainability to lead the charge in innovative ways to reduce greenhouse gas emissions in the healthcare industry.

Industry Sector

The industrial sector includes industry activities such as the processing and manufacturing of physical and chemical materials. The Hampton Roads region includes iron and steel production and pulp and paper industries. The majority of emissions in this sector result from the combustion of fossil fuels to power processes. Emissions from industrial processes can be difficult to reduce, especially processes such as cement and concrete production that involve chemical reactions producing emissions that cannot be avoided without changes to chemical processes. The measures identified for this sector reflect current technological and policy trends to reduce industrial emissions, including improving process efficiency and fuel switching.

I1. Support emissions reductions from industrial processes

While industrial processes vary significantly across industrial operations, nearly all have opportunities to enhance their thermal or electrical efficiency. In addition to efficiency, this measure seeks to decarbonize industrial operations through the electrification of low and medium temperature processes, and where possible, high heat temperature processes, and by changing industrial processes which generate GHG emissions. However, many industrial processes rely on either high temperature operations which are not easy candidates for electrification or produce GHG emissions from chemical processes and iron, steel, and other metal production, among other industrial processes. Nationally, these areas have been a focus for research and pilot development by federal agencies such as DOE and EPA.

Key Actions

- **Coordinate with the healthcare sector to better understand their role in contributing to GHG emissions and potential reduction measures**
  - Work with the Sentara Sustainability Director to implement energy tracking software for the 12 hospitals and hundreds of care sites in the MSA. Use both educational and energy cost avoidance tools to reduce their usage of unnecessary equipment, encourage best practices, and provide cost savings.
  - Coordinate a workshop with the commercial sector to share Sentara's successes and promote additional information sharing and cost-effective strategies.
  - Partner with Sentara to analyze climate related diseases that impact healthcare in the MSA and how they can be mitigated through GHG reduction efforts.
  - Identify contacts in other regional healthcare systems (e.g. Riverside and Bon Secours) to share best practices and coordinate on reduction measures.
- **Support the development of strategic sustainability plans for C&I facilities**
  - In Hampton Roads, the Port of Virginia leads by example (see Measure I2).
- **Develop a long-term regional plan to identify industrial sites with opportunities for hydrogen production and/or use, carbon capture, electrification, or use of other low-carbon fuels, or other reduction measures**
- **Coordinate with the DOE to better understand opportunities to participate in demand response programs**
  - The Commonwealth works with Voltus to curtail energy usage during high peaks and conserve for critical uses, government buildings, universities, industry, schools, etc. can participate in these programs.

Key implementers

- **Utilities.** Engaging with local electric and gas service providers (e.g., Dominion Energy, Columbia Natural Gas) for the MSA will be important to ensure electrical grid stability and reliability to support increased electric loads from electrification; to support infrastructure development for hydrogen fueling stations; and to support use and blending of renewable natural gas. Related stakeholders providing grid services such as demand response at industrial facilities can help mitigate energy use and grid impacts.
- **State and federal agencies.** State and federal agencies may provide R&D, funding, and project support, especially for the use of emerging technologies and solutions.
- **Private sector partners.** Private companies that own/operate facilities will be the ultimate implementers of this measure.

Metrics for Tracking Progress

While these metrics would help track changes in energy, emissions, and project implementation over time, the data collection and reporting processes may not currently be in place to support these metrics.

- GHG and other pollutants emission reductions
- Amount of energy savings from efficiency projects
- Number of pilot projects in the region for innovative low-carbon solutions, such as the use of hydrogen

I2. Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes

This measure focuses on reducing GHG emissions through actions to decarbonize operations and electrifying ports, building upon and furthering progress made under the Port Net Zero Programs and infrastructure and electrification upgrades. On the shoreline of ports, the measure could involve deploying shore power (electric power supplied to docked ships to reduce idling), installing renewable energy, and switching to electric forklifts and other cargo handling equipment, among other activities.

Virginia Port Authority (VPA) - VPA owns and operates (through its private operating subsidiary, Virginia International Terminals, LLC) four general cargo facilities Norfolk International Terminals (NIT), Portsmouth Marine Terminal (PMT), Newport News Marine Terminal (NNMT), and the Virginia Inland Port in Warren County. The port also leases and operates the Viginia International Gateway (VIG) and Richmond Marine Terminal (RMT; outside the MSA).

Key Actions

- **Support Port Net Zero Programs from VPA's Sustainability Report**
  - Continue to source clean energy for port operations. VPA has met their 2024 goal of utilizing 100% clean energy sources. All terminals except VIP are covered by a PPA with Dominion Energy. VIP is served by a green rider via Rappahannock Electric Co-op for the last 3 years.
  - Expand and enhance existing programs to increase the implementation of current Port Net Zero initiatives, such as the Green Operator (GO) program. GO was expanded two years ago to have a new at- and near-zero funding option as well as the legacy diesel replacement program. The port has also for the last 9 -10 years been electrifying terminals via sweeping multimillion dollar projects. During this time the Port has spent over $1B on modernizing the terminals and incorporating cleaner equipment. The Port currently has the northern half of NIT under construction expanding this same technology there.

- Advance Port Net Zero projects through additional studies, pilot projects, and grant work. The Port has completed most studies needed at this time including electric drayage, hybrid shuttle carriers, hydrogen and electrical studies, as well as a few other studies over the past 2-3 years, leading up to the net zero commitment. The Port also recently performed an emissions study and will do so again at the end of the clean port grant in a few years.

- **Continue port electrification and infrastructure upgrades**
  - Continue to fund VPA's GO drayage truck replacement program. There is funding remaining in 2025 for about 8 trucks. The Port will then apply for the next round of programmed state-level funding, about $500K each year for the next few years.
  - Design, deploy and use programs and incentives to decarbonize/electrify ports. With state and federal funding, and following the implementation of the Clean Ports grant, the Port will have NIT and RMT nearly fully on electric and battery power, VIG will be over half. Additional studies are needed for NNMT and the future of VIP. PMT is still being used for the Dominion project and will be for several years by lease arrangement.
  - Explore expanding I-64 barge operations to reduce VMT of port-supporting vehicles. The barge provides an alternative to truck transport and saves on emissions compared to diesel dray trucks. The barge has been expanded to the current level of service over the last several years. Both a new barge and trips between Hampton Roads ports and RMT were increased to up to 3 times per week as needed depending on demand. The Port currently has the service optimized to address customer needs.
  - Evaluate potential for the provision of shore power or alternative fuels to reduce emissions from oceangoing vessels. Each year staff look at how long vessels stay alongside. Less than 10% are here for more than 24 hours. Until this increases the Port will likely not consider shore power.
  - Complete the transition of the central rail yard at NIT from diesel to electric and begin designing the second phase of this improvement. A new rail bundle has been added and is in operation along with new electric cantilever rail-mounted gantry (CRMG) cranes. The Port only has one switcher locomotive remaining that is not an electric or hybrid piece of equipment. The Port already moves more cargo by rail than any other east coast port. Depending on the time of year, the Port has been hovering around 40% of our cargo being moved on rail.
  - Convert traditional operations at North NIT to electric options. Construction is ongoing with two years to complete.
  - Engage in detailed electrical work for equipment charging on the terminal. This is ongoing for the Clean Ports Grant at NIT and RMT.
  - Coordinate with power providers for port electrification by pre-planning infrastructure to avoid future disruptions and ensure resilient siting of chargers to prevent flooding. This is being worked during design, upgrades with Dominion have been discussed. A second substation is currently under construction on NIT. Investigations are underway at RMT as well.
- **Enhance communication and recognition**
  - Engage the community through quarterly newsletters and the Port's annual sustainability report. Seek recognition through industry awards in maritime and other transportation groups. There is periodic civic league engagement as well las participation in special events.

Virginia Port Authority

A recipient of the EPA Clean Ports grant program, the Virginia Port Authority (VPA) is well on its way to achieving net zero carbon emissions for operations by 2040.

VIG Liebherr Lift. Source: The Port of Virginia

The Port of Virginia has transitioned **100%** of operations to be sourced from **clean energy**, and VPA continues to electrify and conduct infrastructure upgrades at all facilities.

- **Encourage other partners to achieve sustainability goals**
  - Continue the partnership with Norfolk Southern to promote and expand the RailGreen Corridor between Front Royal and Norfolk, VA. Shippers hauling freight along this segment may purchase carbon reduction certificates. Funds from the sale of the certificates will be used for Norfolk Southern to buy more low-carbon biofuel. The shippers will receive environmental attribute certificates quantifying and tracking their emissions reductions.

Key implementers

- **VPA.** VPA owns and operates (through its private operating subsidiary, Virginia International Terminals, LLC) four general cargo facilities NIT, PMT, NNMT, and the Virginia Inland Port in Warren County. The port also leases and operates the VIG and RMT (outside the MSA).
- **Utilities.** Engaging with local electric and gas service providers (e.g., Dominion Energy, Columbia Natural Gas) for the MSA will be important to ensure electrical grid stability and reliability to support increased electric loads from electrification and to support the use of low carbon fuels.
- **Trade groups.** Trade groups will implement the infrastructure updates specified in this measure.
- **Private sector partners.** Private companies and landowners with property near port infrastructure may need to be engaged to coordinate land use planning. VPA has good relationships with other private sector partners including original equipment manufacturers which play a vital role in efforts covered by this measure.
- **Community colleges.** VPA works with Tidewater Community College to provide necessary training for technical operators and maintenance technicians.
- **Regional planning agencies.** HRPDC has previously provided support to VPA.

Metrics for Tracking Progress

For the Port of Virginia, VPA is already tracking the following metrics:

- CO_2e tons per 10,000 twenty-foot equivalent unit (TEU)
- Fuel gallons per 10,000 TEU
- Percent electric equipment
- VIG turn-time
- NIT turn-time

Hampton Roads Climate Action Plan
WASTE & WASTEWATER

SOLID WASTE accounts for 90% of waste emissions

WASTEWATER accounts for 10% of waste emissions

How does the waste sector emit greenhouse gases?

Organic material in landfills and wastewater treatment plants is broken down by bacteria, naturally releasing **methane** and other **greenhouse gases.**

Just a **small amount of methane** can add to the greenhouse effect, causing more warming.

Hampton Roads Sanitation District (HRSD) operates 14 wastewater treatment plants in Virginia, serving 1.9 million customers with 500 miles of pipes and the capacity to process 225 million gallons per day.

VOICES HEARD AROUND THE REGION...

"...all public buildings should be required to recycle, and ... make sure what ends up in the recycle bin [goes to be] recycled..."

"Reopen or build new waste to energy plant to produce electricity from waste, reducing the waste stream to landfills."

How Hampton Roads Can Reduce Emissions From Waste and Wastewater

ACTION	WHAT IT MEANS	KEY BENEFITS
Reduce Waste Sent to Landfills	Expand recycling, composting, and waste diversion to keep food and yard waste out of landfills.	Cuts methane emissions, saves landfill space, and creates local compost and recycling jobs.
Upgrade Wastewater Treatment	Improve efficiency and capture methane from wastewater treatment plants to create renewable energy.	Turns waste into energy, improves water quality, and reduces operational costs.

BUILDING UPON REGIONAL SUCCESSES

Purple bins are available for residents in James City County to drop off glass for recycling.

Hampton Roads Sanitation District is turning biogas, a byproduct of wastewater treatment, into renewable natural gas.

The Start Smart, Recycle Right program, run by askHRgreen.org, provides information to residents on how to recycle right in the region.

askHRgreen.org

Waste and Wastewater Sector

The waste and wastewater GHG emissions sector includes emissions from landfills and wastewater treatment, resulting from the decomposition of organic materials and treatment processes. Common GHG reduction actions include capturing landfill gas for energy, upgrading wastewater treatment technologies, diverting organic waste through composting or anaerobic digestion, and improving recycling and source reduction. Reducing emissions in this sector supports climate goals while also improving public health and environmental quality.

W1. Decrease the amount of solid waste sent to landfill

Focusing on policies, diversion, and education, this measure aims to reduce the amount of waste material being sent to landfills that could otherwise be directed to recycling or composting programs. With reuse, recycling, and composting, organic materials do not degrade in a landfill release GHG emissions and existing materials, like plastics and glass, can continue to be used instead of new stock materials being produced.

Actions

- **Improve regional planning and waste reduction policies**
  - Support regional coordination between solid waste planning units (SPSA and Virginia Peninsulas Public Service Authority (VPPSA)) and localities to align programs and messaging to decrease overall waste generation and reduce the volume of waste sent to landfills and to improve the effectiveness of recycling processes.
  - Develop a Model Ordinance and develop programs to reduce construction and demolition waste through building reuse, deconstruction, and material diversion and reuse.
- **Diversion of recyclable and organic materials from landfills**
- **Create and implement waste diversion programs**
  - Provide case studies and best practices for localities regarding waste diversion programs.
  - Support localities in establishing composting zones.
  - Leverage the development of SPSA's planned automated material recovery facility (MRF) and explore the possibility of expanding application of the technology to the entire region. The planned facility will segregate the waste stream, remove organics for processing through pyrolysis, and sort recyclable materials for recycling.
  - In conjunction with the development of SPSA's new MRF, develop a regional strategy for removal of cardboard and other materials that would be degraded through single stream processing from the waste stream prior to processing at the MRF.
  - Divert waste for bioenergy projects.
  - Invest in glass recycling programs similar to the purple bins used by James City County and the Glass Half Full Initiative.

Glass Recycling

James City County offers a glass-only collection method for recycling. Purple bins are available at the County's Convenience Centers for residents to drop off their glass recyclables and a nearby glass recycler turns them into recycled bottles and other uses.

Glass recycling informative resource. Source: James City County

- **Promote educational initiatives**
  - Expand the Start Smart, Recycle Right recycling and reuse program by creating additional informational videos and resources.
  - Continue to encourage community members to use the askHRgreen.org website to learn more about recycling and composting. Encourage people to utilize the Waste Wizard lookup tool to learn more about the correct places to dispose of items like electronics, glass, batteries, and household goods.
  - Offer additional opportunities to learn more about composting and recycling initiatives and how community members can engage with them. Utilize funding from the VA DEQ CPRG Implementation Grant award on Methane reduction to reach community members.

"...all public buildings should be required to recycle, and ... make sure what ends up in the recycle bin [goes to be] recycled..."– Survey response

Key Implementers

- **Local government and other Sub-State governmental organizations.** Local and other sub-state government entities such as locality Public Works Departments, SPSA, and VPPSA manage landfills and solid waste management. In North Carolina, localities plan and operate services and facilities to meet local needs. Additionally, the Albemarle Regional Solid Waste Management Authority is a regional agency that coordinates waste management for a set of localities in northeast North Carolina including Currituck and Gates counties
- **State government agencies.** In Virginia, DEQ is responsible for oversight and guidance on waste management. In North Carolina, NCDEQ sets the rules, issues permits, inspects/enforces, and provides technical and financial assistance.
- **Private sector partners.** Privately owned waste treatment facilities, haulers, and processing facilities can be voluntarily involved in emissions savings measures and incentivized involvement.

Metrics for Tracking Progress

- Tonnage sent to landfill, recycling, compost, and construction and demolition waste
- Total tonnage per capita, and total waste generated and % diverted in the MSA
- Number of automated recycling systems implemented
- Number of construction/demolition waste reduction programs supported
- Number of waste diversion programs created
- Number of composting zones established
- Amount of waste diverted for bioenergy projects
- Number of methane capture systems expanded or upgraded
- Number of educational initiatives and resources developed

Start Smart, Recycle Right

askHRgreen.org is an online resource center for all clean and green questions in the region. Start Smart, Recycle Right provides information on the right way – and the wrong way – to recycle in the Hampton Roads region.

The information resources help ensure that items get recycled by providing information on how to recycle (including videos!), recycling locations, and how to make waste conscious decisions.

Logo. Source: askHRgreen

- Amount of energy recaptured from any flares using thermal generators and number of projects with beneficial reuse of landfill gas
- Amount of biochar produced
- Increase in community awareness and participation in waste reduction and recycling initiatives

W2. Support efficiency upgrades at wastewater treatment plants

This measure focuses on upgrading technology at wastewater treatment plants so that efficiency improvements and smart technology can be introduced, closing incerators, and harnessing renewable energy from wastewater treatment plants (WWTP).

Key Actions

- **Close incinerators at three major HRSD WWTPs**
  - Reduce emissions related to the burning of natural gas to start up the three closed incinerators at the Boat Harbor WWTP, Army Base WWTP, and closed Chesapeake-Elizabeth WWTP.
  - Reduce emissions from incineration of waste solids by processing them for RNG production at other WWTPs.
- **Implement efficiency upgrades at HRSD wastewater treatment facilities**
  - Evaluate and determine next steps, funding, and project leads for potential pilot and full-scale projects, such as partial denitrification-anammox (PdNA) treatment and exploration of pyrolysis at the Atlantic Treatment Plant to convert a portion of biosolids into biochar.
- **Complete energy audits on all HRSD facilities, identifying opportunities for energy retrofits across its facility portfolio, and integrate findings into HRSD's capital improvement planning**
  - Evaluate the benefits and feasibility of using a contracting method, such as an energy-savings performance contract or energy as a service, to bundle and fund (and potentially identify) energy retrofits.
  - Implement Smart Technology Upgrades. Some upgrades that could be implemented in regional facilities include advanced monitoring systems, automated controls, and energy-efficient machinery.
  - Investigate battery storage/microgrid opportunities to lessen energy costs and time of use cost impacts.
- **Develop systems to create renewable energy from WWTP processes**
  - Operate thermal hydrolysis and anaerobic digestion waste solids treatment at the Atlantic WWTP to produce renewable natural gas (RNG).

Fuel from Wastewater Byproduct

Hampton Roads Sanitation District (HRSD) is partnering with Virginia Natural Gas to produce renewable natural gas (RNG).

- Biogas, a byproduct of wastewater treatment, will be converted to renewable natural gas
- Virginia Natural Gas plans to invest **$30 million** in the Atlantic Treatment Plant and the RNG will be added to an existing pipeline

The RNG will power up to **4,000 homes** in a year.

HRSD's Atlantic Treatment Plant in Virginia Beach. Source: WHRO Public Media

- Develop a comprehensive program to capture and convert waste gases from WWTPs into renewable energy sources, such as biogas, to reduce emissions and generate sustainable energy.
- Treat nearly all (98%) solids formerly incinerated at the Chesapeake-Elizabeth WWTP at the Atlantic WWTP to produce RNG. Treat a significant portion of solids formerly incinerated at the Army Base WWTP at the Atlantic WWTP to produce RNG. Explore opportunities to implement RNG projects at other WWTPs, or modify solids handling across HRSD facilities to divert additional waste solids to RNG production.

Key Implementers

- **State and Sub-State governmental organizations.** HRSD has authority to implement energy programs, policies, and projects within its operations and facilities. To enact specific decarbonization projects, policies, or/or pilot programs, HRSD may need to gain approval from its Board of Commissioners, a City Council or County Board of Supervisors, or other administrative authority that oversees budgets and/or regulations. Agencies like the VA Department of Professional Occupational Regulation are responsible for licensing wastewater facilities.

Metrics for Tracking Progress

- Number of energy audits conducted and resulting amount of energy savings potential and upgrades identified
- Volume of emissions reduced from discontinuing the incineration of waste solids
- Volume of emissions reduced by discontinuing natural gas combustion for three incinerator furnace startups
- Volume of waste gases captured and converted into renewable energy
- Number of smart technology upgrades implemented and corresponding amount of energy savings
- Increase in RNG energy generation from biogas
- Reduction in operational costs due to energy savings
- Enhanced monitoring and control of wastewater treatment processes
- Increased energy efficiency of wastewater treatment plants

Moving Towards Implementation

To effectively address these measures, public and private partners will need to actively pursue these policies and programs. The CCAP is a community-based effort that relies on the participation and cooperation of local governments, businesses, NGOs, and residents. By working together, the Hampton Roads region can implement innovative solutions, share resources, and create a resilient and sustainable future for all.

While there will be some areas of low-hanging fruit that our region can pursue in the next 1-3 years, other recommendations will take longer to implement due to the scope of the initiatives or available funding sources needed to support their advancement. The recommendations in this CCAP were developed, however, with broad-based community and stakeholder input and will be sound strategies that can be advanced over the next 10-20 years.

Many of the CCAP implementation actions have direct relationships with ongoing efforts at locality and regional levels. As a result, they will not require changes of philosophy or the creation of new programs. Examples of ongoing efforts that will complement CCAP actions include:

- Locality and business efforts to electrify transportation fleets and expand the use of low emission vehicles powered by propane and renewable natural gas
- Installation of EV charging stations at government and business locations
- A 250-mile interconnected bike/walk trail system across Hampton Roads that will eventually connect the following individual trails into one region-wide network:
    - Virginia Beach Trail
    - Elizabeth River Trail
    - Virginia Capital Trail Extension
    - Dismal Swamp Canal Trail
    - East Coast Greenway
    - Chesapeake Bay Southside Loop
    - South Hampton Roads Trail
    - TRAIL757
- The 757Express – 13 bus routes that will create a transit backbone to interconnect the region's localities with consistent 15-minute service interval
- Transportation improvement projects including traffic signal timing that reduce congestion and improve air quality
- Green infrastructure planning and open space preservation programs
- Energy conservation programs and practices
- VPA's extensive clean energy and net zero GHG emissions program

No one sector will be fully responsible for the implementation of CCAP actions. Local government will have a role, but the responsibility for implementation will be equally shared by the business and non-profit communities as well as regional residents who will voluntarily embrace some of the recommendations due to economic, convenience, or quality of life reasons.

It is important to understand that any plan is a long-term strategy developed with available information at a particular point in time. While we have made every effort to develop an effective plan and strategy, we are committed to monitoring the effectiveness of the recommendations and make adjustments over time for the benefit of our region. In the near term, HRPDC will continue tracking progress over the next 2 years to inform the 2027 CPRG status report.

Benefit Analysis

Benefits Analysis

In addition to GHGs, emissions from CAPs also harm public health and the environment, and HAPs are pollutants known to cause cancer and other serious health impacts. Like a GHG inventory, tracking these co-pollutants in an inventory over time provides an understanding of what pollutants are being released, how much, and their key sources. See Table 2 for a summary of co-pollutant emissions in the region by sector and pollutant, with a focus on CAPs. These pollutants have widespread public health impacts, including increased incidents of respiratory and cardiovascular diseases, asthma exacerbation, and premature death. Reducing CAPs improves health outcomes, reduces healthcare costs, and improves livelihoods and quality of life. CAPs were prioritized in this report due to their regulatory significance and the availability of robust emissions factors and monitoring methods.

This section presents the quantified outcomes of co-pollutant changes and associated health benefits for the MSA building from the modeling conducted for the net zero CCAP implementation scenario. The MSA-wide summary results provide an aggregated view of total emissions reductions and health impacts across all sectors. Sector-specific analyses detailing the contributions of individual sectors to both pollutant reductions and public health improvements can be found in Appendix B. Key benefits of implementing measures include:

- **Health Improvements**: fewer asthma attacks, hospital visits, heart and lung diseases, and premature deaths, with a potential value of $1.5 - $3 billion.
- **Economic Gains**: reduced medical costs, improved worker productivity, and new clean energy jobs.
- **Community Resilience**: cleaner indoor and outdoor air, greater energy reliability, cooler neighborhoods, and improved natural systems.

Transitions to low-carbon technologies provide far-reaching benefits. By reducing air pollutants, these measures may improve respiratory and cardiovascular health, enhance day-to-day quality of life, and build more resilient communities. Across sectors, the shift away from fossil fuels has the potential to cut pollution at its source and bring meaningful improvements to both local environments and public well-being. Together, these sector-wide transitions deliver substantial air-quality, health, and resilience gains alongside climate progress.

In **transportation**, vehicle electrification eliminates tailpipe emissions and reduces noise, improving air quality and livability in neighborhoods near busy roads. Cleaner **buildings**, driven by the adoption of heat pumps and efficiency upgrades, lower indoor and outdoor exposure to combustion-related pollutants. A cleaner electric **power** sector reduces emissions from fossil plants, strengthens grid resilience, and can lower energy bills. **Industrial** facilities that adopt cleaner fuels and more efficient processes lessen pollution burdens on nearby communities, while improved **waste** practices curb methane and co-pollutants and create opportunities for biogas and compost use. **Agricultural** practices that restore soil health reduce emissions, protect water and land resources, and improve resilience to extreme weather. Finally, investing in **trees** and better **land management** cools neighborhoods, improves air filtration, and enhances ecosystem services. Together, these sector-wide transitions deliver substantial air-quality, health, and resilience gains alongside climate progress.

Reducing GHG and co-pollutant emissions has and will continue to have profound implications for **public health** of residents of the Hampton Roads MSA. The combustion of fossil fuels contributes to outdoor and indoor air pollution which, in turn, poses significant health risks. In the United States, roughly 87% of people's lives are spent indoors, so indoor exposure to combustion pollutants, such as natural gas for cooktops or heating, has the potential for substantial health effects.[10] In instances of long-term exposure, these health effects can include premature mortality, adverse birth outcomes, cognitive decline, and

[10] U.S. EPA. 1989. *Report to Congress on indoor air quality: Volume 2. EPA/400/1-89/001C.* https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9100LMBU.TXT

gastrointestinal inflammatory disease. Short-term exposure can lead to asthma and respiratory symptoms.[11] Furthermore, the adverse health impacts extend to climate impacts such as extreme heat events. Nearly two-thirds of the U.S. population resides in areas susceptible to health risks related to extreme heat, including heat-related illnesses and cardiovascular conditions.[12]

Health impact estimates, derived from EPA's Co-Benefits Risk Assessment (COBRA) tool, include both incidence counts and monetized benefits across categories such as mortality, hospital visits, restricted activity days, and respiratory/cardiovascular conditions. COBRA is a screening tool developed by EPA to estimate the health and economic benefits of air quality improvements. COBRA models the impact of changes in emissions of key air pollutants (e.g., $PM_{2.5}$, SO_2, NO_X, VOCs) on public health outcomes and monetizes these benefits using peer-reviewed concentration-response functions and economic valuation methods.

Table 4: Cumulative Changes in Co-Pollutant Emissions (MT) by Pollutant, 2025-2050

Pollutant	Cumulative Reductions from Change in Energy Use	Removals from NWL
NO_x	16,89	42,954
SO_2	35,679	52,881
PM	4,814	123,523
CO	40,015	3,898
Lead	0.34	0.0
VOC	632	0.0

In addition to health benefits from air pollution removals, the **natural lands sector** provides ecosystem services in the form of avoided runoff, rainfall interception, and transpiration, which helps combat urban heat island effects, enhance stormwater management by managing water volume, and improve water quality by reducing stormwater runoff and promoting infiltration. To assess the co-benefits of natural and working lands, EPA's i-Tree Landscape Module was used to estimate ecosystem services provided by increased tree cover. By 2050, the modeled tree canopy expansion could result in avoided runoff benefits reaching over $23 million per year.

Table 5: Cumulative Monetary Health Benefits and Incident Reductions, 2025-2050, Million $

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$1,466 -$2,878	100-197
Hospital Visits	$1.2	214
Missed School/Work or Restricted Activity	$ 41	92,145
Cardiovascular Conditions	$4.5	61
Respiratory Conditions	$ 44	69,167

The CCAP also has the potential for substantial **socioeconomic** benefits. For example, clean energy can be developed to improve grid resilience (e.g., through battery storage), reducing the risk of blackouts and promoting energy independence.[13] Consequently, these investments mitigate the economic and physical impact of extreme weather events. Additionally, reducing GHG emissions over the long term can help increase climate resilience and lessen occurrences of events like extreme precipitation and storms. This, in turn, can prevent additional costs such as higher insurance premiums, expenses for repairing structural damage, and losses in crops and natural resources. The reduction of extreme weather events also alleviates costs

[11] Health Effects Institute. 2020. *Health Effects Institute Annual Report 2020: Valuing Science Informing Decisions.* https://www.healtheffects.org/system/files/hei-annual-report-2020.pdf
[12] CDC. 2024. *Heat Risk Initiative.* https://www.ama-assn.org/public-health/environmental-health/cdc-heat-risk-initiative-air-pollution-statistics-and-latest
[13] NREL. 2018. *Distributed Energy Planning for Climate Resilience.* https://www.nrel.gov/docs/fy18osti/71310.pdf

related to medical bills and premature deaths. In 2022 alone, the U.S. faced 18 extreme weather and climate events costing over $1 billion, making the reduction of these costs crucial for individual, community, and overall economic wellbeing.[14]

Implementing the measures in this plan across all sectors would lead to changes resulting in reductions of all criteria air pollutants from 2025 – 2050. Table 4 shows the cumulative reductions by pollutant. **Error! Reference source not found.** then presents the monetized health benefits from improved public health due to the lower co-pollutant emissions, which may range from $1.5 - $3 billion. The alleviation of these pollutants will positively impact the physical and economic wellbeing of communities. In the long run, the reduction of GHGs will help mitigate climate change.

[14] NOAA. 2023. *2022 U.S. billion-dollar weather and climate disasters in historical context*. https://www.climate.gov/news-features/blogs/beyond-data/2022-us-billion-dollar-weather-and-climate-disasters-historical

Workforce Assessment

Workforce Assessment

Assessing the readiness of the workforce to support implementation of the measures is a critical step to successful implementation. This section focuses on occupations that are likely to be directly impacted by the CCAP measures, identifies potential gaps in worker availability and training, and outlines a solutioning framework. More detail on the workforce analysis approach and methodology, including employment trends, gap analysis data, and the skills and training assessment can be found in Appendix C.

This workforce analysis provides information to help the region proactively plan for future workforce needs. The CCAP is projected to directly impact about 50 different occupations ranging from farmers to electricians. In total, these occupations represent roughly 88,100 jobs or 9.9% of total jobs in the MSA.

The workforce gap analysis uses data on projected growth, separations, and hires to estimate the occupations with excess and deficits. The gap analysis is based on existing conditions in the labor market and does not consider the workforce shifts that may occur from the implementation of CCAP measures. It is a starting point to identify current areas of shortages and to identify areas for future collaboration and planning to ensure workforce readiness. As measure implementation occurs across sectors, workforce needs will grow for hands-on positions within waste, construction, plumbing, and carpentry, and existing workers may need to undergo additional training (e.g., electricians that can install EV chargers and HVAC technicians that can install heat pumps).

Gap Analysis Takeaways

Overall, the Hampton Roads MSA has very good equilibrium in its labor market for the CCAP occupations, with only some relatively minor shortages or surpluses (i.e., supply is within 1-4% of demand for most occupations).

The largest shortage expected in 2025 is 339 laborers and freight, stock, and material movers in the agriculture and natural lands and off-road transportation (e.g., ports) sectors (see Table 6). These include seasonal and part-time laborers and represent 2.8% of the total occupation in the MSA. Most of the remaining top occupations with near-term shortages also lie in the transportation (ports, drivers) and agriculture and natural lands sectors. Some of these shortages may require technical training or a secondary degree, while others may be entered directly after high school.

Workers address flooding at Eastern Virginia Medical School. Source: HRPDC

In the transit space, HRT is working with a consistent shortage of 40-50 bus operators, which is limiting how quickly further expansions of the 757 Express can be implemented. HRT is currently assessing options to ensure the current system routes are sustainable while considering strategies to more effectively attract new hires. One of the primary challenges faced by bus operators is quality of life concerns, leading to a smaller pool of potential workers.

Workforce surpluses in the region are also relatively minor for CCAP occupations (see Table 7). The largest workforce surplus expected in 2025 is 357 light truck drivers, representing 7% of the total workforce in that occupation. This is followed by an excess of 300 construction workers, 172 carpenters, and 161 electricians. It is important to note that that while some occupations have projected surpluses, the individuals still may not have the technical knowledge to implement CC AP measures in areas on EVs, energy efficiency and auditing, and solar photovoltaic (PV) installation. Part of the solutioning

framework is to connect individuals with technical skills to upskilling opportunities that will prepare them to support the implementation of the CCAP.

Table 6: Occupations with the Largest Expected Shortage in 2025

			Expected Supply	Expected Demand		Expected Shortage	
Occupation	Relevant Sector	Projected Employment	Hires	Growth (New Jobs)	Projected Separations	Workforce Shortage	Shortage (% of Total Employment)
Laborers and Freight, Stock, and Material Movers, Hand	Ag and Natural Lands, Transportation	12,058	13,105	84	13,360	-339	2.8%
Heavy and Tractor-Trailer Truck Drivers	Transportation	8,814	5,782	87	5,761	-66	0.7%
Ship Engineers	Offroad Transportation	1,203	762	-11	791	-18	1.5%
Forest and Conservation Workers	Ag and Natural Lands	40	158	-1	173	-14	36.6%
Sailors and Marine Oilers	Offroad Transportation	2,389	1,387	-21	1,420	-12	0.5%
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	Ag and Natural Lands	509	818	2	827	-11	2.2%
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Transportation	742	381	24	367	-10	1.3%
Farmworkers, Farm, Ranch, and Aquacultural Animals	Ag and Natural Lands	300	331	-2	337	-4	1.4%
Agricultural Workers, All Other	Ag and Natural Lands	118	166	0	170	-4	3.3%
Solar Photovoltaic Installers	Buildings and Energy Supply	28	21	1	23	-3	9.5%

Table 7: Occupations with the Largest Expected Surplus in 2025

			Expected Supply	Expected Demand		Expected Surplus	
Occupation	Relevant Sector	Projected Employment	Hires	Growth (New Jobs)	Projected Separations	Workforce Surplus	Surplus (% of Total Employment)
Light Truck Drivers	Ag and Natural Lands, Transportation	5,103	5,429	214	4,859	357	7.0%
Construction Laborers	Buildings, Transportation	6,723	4,763	7	4,456	300	4.5%
Carpenters	Buildings	5,062	2,490	-54	2,373	172	3.4%
Electricians	Buildings, Transportation	5,832	2,544	31	2,352	161	2.8%
First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Transportation	5,559	2,104	-13	1,960	157	2.8%
Operating Engineers and Other Construction Equipment Operators	Transportation	2,457	1,338	2	1,226	110	4.5%
Plumbers, Pipefitters, and Steamfitters	Buildings	3,870	1,820	-1	1,717	104	2.7%
Helpers--Electricians	Buildings, Transportation, Energy Supply	678	1,184	-2	1,103	83	12.3%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	3,371	1,704	7	1,624	72	2.1%
Landscaping and Groundskeeping Workers	Ag and Natural Lands	5,933	4,256	0	4,206	49	0.8%

Future Considerations

Although workforce shortages are relatively minor today, the rapid pace of change needed to implement the CCAP will require a significant change in the workforce and exacerbate existing challenges and barriers to attracting and retaining workers. Strategies for addressing these shortages include establishing a workforce pipeline, upskilling and reskilling workers, and coordinating with regional partners to scale existing successful programs in the region. Effective coordination and planning will ensure that workforce needs for the CCAP are addressed, allowing for seamless and efficient implementation.

Upskilling and Reskilling

One way to address the workforce imbalances within the MSA is to match surplus occupations with occupations that have shortages. For example, laborers and freight, stock, and material movers are facing a current shortage while construction laborers in the buildings sector have an expected surplus. These occupations have transferable skills and cater to a similar workforce population that is physically able to perform hands-on tasks. This could be an example of upskilling because in some scenarios workers may only have to learn some new information or practices and their type of work would remain the same. However, it could also be considered reskilling in some situations where a laborer was focused on off-road transportation but was being transferred to on-road which would require new skills. Upskilling and reskilling can both be great opportunities to bridge gaps in the workforce and provide community members with opportunities for professional development and career advancement.

Early Career Professional Pathways

It is critical to introduce young residents to career pathways beyond traditional four-year institutions. There are numerous one- and two-year training options that can equip students with technical expertise to be HVAC, autobody, and electrical technicians. Additionally, there are careers that do not require any education beyond a high school diploma where individuals can make direct positive impacts. Some existing programs in the region include:

- NextGen pathways is a career resource in Hampton Roads that has a range of programs from internships to a career guidance academy and youth programing.
- WIOA Youth Programs are year-round and organized by the Hampton Roads Workforce Council. It offers a range of out-of-school programs for students ranging from maritime studies to medical support to cyber security. It is funded by the Workforce Innovation and Opportunity Act.
    - The Youth Workforce Center is focused on providing students with professional pathways in high demand occupational sectors. They provide technical training and job placement assistance.
    - Virginia Technical Academy (VTA) is focused on technical skills in HVAC, electrical, plumbing, appliance repair, and building maintenance. This out-of-school program can provide students with necessary certifications and skills for direct employment opportunities.
- Virginia Beach City Public Schools' (VBCPS) Career and Technical Education (CTE) programs provide students with early career exposure to science, technology, engineering, and math (STEM) opportunities, in addition to dual enrollment credits, and opportunities to work with local businesses.

Hampton Roads Workforce Council (HRWC)

HRWC is focused on ensuring that there is a variety of workforce development resources and initiatives within the region. They offer services on maritime and infrastructure training in addition to veteran and general career development resources. They recently launched a program aimed to decrease the shortage of maritime workers called Pathways to Shipbuilding.

These programs introduce students to a broad spectrum of career paths and opportunities that are essential for fostering long-term professional growth and adaptability in a changing workforce.

Workforce Development Partners

Workforce development partners bridge community needs with career opportunities. These groups are deeply embedded in the economic success of the region and provide crucial expertise to community members seeking employment or opportunities to develop professionally. Some key workforce stakeholders in the HPRDC region include:

- Hampton Roads Alliance brings together industry partners, community members, and local governments together to drive economic development in the region. They hold a breadth of knowledge surrounding employment and business development in HRPDC.
- STOP Organization provides individual and group support for employment. They provide a full suite of services including covering transportation costs to interviews, resume editing, employment counseling, and many others.

Centura College Wind Turbine Technician Program

This 12-month course provides students with the skills necessary to install, maintain, and repair wind turbines. Being able to work on wind turbines is a crucial skill to supporting clean energy development in the region. The program also offers students opportunities to further enhance their knowledge with certificates focused on maritime and power industry skills respectively.

Community Colleges and Technical Schools

Working with community colleges and technical schools is extremely important to ensure that the emerging workforce has access to necessary certifications and technical expertise to be able to implement the CCAP. Higher education partners in the region include:

- Centura College is offering a 48-week wind turbine technician program.
- Virginia Peninsula Community College Workforce Development offers programs in HVAC, carpentry, electrical, and many others.
- Tidewater Community College provides technical courses on maritime trades, HVAC, and engineering.
- Community Housing Partner's Training Center: Housed in Virginia, this center offers training to weatherization and energy professionals.

Utilities

Utilities can provide guidance on key workforce gaps and employment opportunities in the region. Dominion Energy is the primary energy provider in Virginia and they are currently developing the Coastal Virginia Offshore Wind (CVOW), the largest offshore wind project in the U.S. In addition to offshore wind deployment, utilities will be critical partners in developing the workforce in emerging job areas to support new nuclear and the low carbon fuels infrastructure in the region.

Appendix A. EPA CPRG Grant Compliance

Summary of Air Quality Plan Elements and Location within Report

AIR Quality Plan Element	Document Location
GHG Inventory and Projections	GHG Emissions Inventory and Appendix B
GHG Reduction Targets	Mitigation Measures and Appendix B
Review of Authority to Implement for Each Measure	Authority to Implement
Plan to Leverage Other Federal Funding for Each Measure	Funding Sources
Quantified GHG Reduction Measures	Pathway to Net Zero and Appendix B
Benefit Analysis	Benefits Analysis and Appendix B
Workforce Planning Analysis	Workforce Assessment and Appendix C

Appendix B. Technical Methodology

This Technical Appendix covers the main quantification elements of the Comprehensive Climate Action Plan (CCAP), including methodologies for the GHG inventory, business as usual (BAU) projections, measure GHG reductions and costs, and co-pollutant impacts.

GHG Inventory

The GHG inventory provides a comprehensive account of emissions within the metropolitan statistical area (MSA) for calendar year 2022. It includes emissions from stationary energy, transportation, waste and wastewater, industrial processes and use, and agriculture, as well as carbon fluxes from natural and working lands, including carbon sequestration from forests and other land-based sinks. Emissions are expressed in metric tons of CO_2-equivalent ($MTCO_2e$) using 100-year Global Warming Potentials (GWPs) from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). The methodologies and data sources used to quantify emissions from each subsector are described below.

Stationary Energy (Buildings)

Residential Buildings

Emissions from residential buildings result from the combustion of fossil fuels for space heating, water heating, and cooking, and from electricity use in appliances. Stationary energy emissions from residential buildings were calculated using Virginia and North Carolina's, natural gas, and other fuel consumption data as derived from Environmental Protection Agency's (EPA) State Inventory Tool (SIT) Stationary Combustion and CO_2 from Combustion of Fossil Fuel modules. The state-level data were then scaled to the counties within the MSA based on a population scaling factor.

Residential electricity emissions were calculated using U.S. Energy Information Administration's (EIA) State Energy Data System (SEDS) residential sector energy consumption estimates for total electricity use for Virginia and North Carolina. The consumption data were multiplied by the 2022 grid emission factor for the SRVC eGRID region. The state electricity emissions data were then scaled to each county using population.

Data sources include:

- EPA State Inventory Tool (SIT)
- U.S. Census Bureau
- EIA State Energy Data System (SEDS)
- EIA Annual Energy Outlook (AEO) 2023

Commercial and Institutional Buildings and Facilities

Commercial and institutional building emissions result from the combustion of fossil fuels for space heating, water heating, and cooking and electricity use in appliances in commercial, government, industrial, data centers, and other non-residential buildings and facilities. Emissions for commercial buildings were calculated using natural gas and other fuel consumption data acquired from EPA's SIT Stationary Combustion and CO_2 from Combustion of Fossil Fuel modules. The state-level data were then scaled to the counties within the MSA based on an employment scaling factor.

Commercial electricity emissions were calculated by scaling SEDS commercial electricity consumption data for Virginia and North Carolina using the employment scaling factor. The consumption data were then multiplied by the electric grid emissions factor for the SRVC eGRID region for 2022.

Data sources include:

- EPA State Inventory Tool (SIT)
- U.S. Bureau of Labor Statistics (BLS)
- EIA Annual Energy Outlook (AEO) 2023

Manufacturing Industries and Construction

GHG emissions result from the combustion of fossil fuels for energy use in industrial buildings and processes, as well as from electricity consumption and power equipment. Emissions for stationary industrial buildings were calculated using two data sources: SIT and facility-specific data obtained from EPA's Greenhouse Gas Reporting Program (GHGRP). SIT data downscales national data to the state level whereas GHGRP requires annual reporting of greenhouse gas emissions from large industrial greenhouse gas emitters.

The emissions data from SIT were scaled down to the county level using employment data population and then compared with GHGRP emission data for each county. If GHGRP emissions were larger than SIT emissions for a county, the GHGRP value was used. If scaled SIT emissions were larger, the difference between the SIT and GHGRP emissions were noted, and the SIT value was used as a conservative approach.

Electricity consumption for Virginia and North Carolina was calculated using industrial megawatt hours values from SEDS. To calculate emissions for the state, the consumption data was multiplied by the electric grid emissions factor for the SRVC eGRID region for 2022. The emissions were then downscaled from the state to county level using employment data.

Data sources include:

- EPA State Inventory Tool (SIT)
- EPA Greenhouse Gas Reporting Program (GHGRP) Facility-Level Information on Greenhouse Gas Tool (FLIGHT)
- EIA State Energy Data System (SEDS)
- EIA Annual Energy Outlook (AEO) 2023

Energy Industries

Emissions from energy industries include all emissions from energy production and energy use in energy industries, such as emissions from generation of energy for grid-distributed electricity, steam, heat, and cooling. Calculation of these emissions depends on whether the GHG inventory is a consumption-based or generation-based inventory.

Consumption-based: For a consumption-based GHG inventory, the only emissions calculated for this subsector were emissions from any energy consumed directly by an energy production facility. For example, electricity consumed at an electricity generation facility. To estimate these emissions, the consumption data were multiplied by the following emission factors:

- Region-specific CO_2, CH_4, and N_2O emission factors from utilities or obtained from EPA's eGRID.
- Fuel-specific CO_2, CH_4, and N_2O emission factors from EPA's GHG Emission Factor Hub.

Otherwise, emissions from energy production (e.g., electricity generation) were allocated to the end-use sector where that energy is ultimately used (e.g., residential buildings, commercial buildings, transportation, etc.) as Scope 2 emissions.

Generation-based: For a generation-based GHG inventory, Scope 1 emissions from individual energy production facilities within the MSA were calculated based on the type of fuel consumed, amount of fuel consumed, and/or amount of energy generated. These emissions were not allocated to their end-use sectors due to lack of available data. As a result, Scope 2 emissions within the MSA were not calculated for any sector to avoid double-counting. To estimate these emissions, these data were acquired from EPA's eGRID 2022 dataset, which contains 2022 CO_2, CH_4, and N_2O emissions data for all power plants in the MSA. Emissions for each gas were multiplied by the IPCC AR5 GWP and summed as carbon dioxide equivalent emissions.

It was assumed that eGRID's adjusted CO_2 emissions represent fossil emissions, and that the difference between eGRID's unadjusted and adjusted CO_2 emissions represents biogenic CO_2 emissions. eGRID's unadjusted CH_4 and N_2O emissions were used in the inventory to ensure non-CO_2 emissions from biogenic sources were accounted for. Note, generation-based emissions were only used for informational purposes.

Data sources include:

- EPA eGRID
- EPA GHG Emission Factor Hub

Fugitive Emissions from Oil and Natural Gas Systems

Fugitive methane emissions from oil and natural gas systems come from leakage of methane from these systems, such as from natural gas distribution pipes. These emissions were calculated by multiplying the natural gas energy consumption from each county by an energy density of 41.7 MJ/kg and a leakage rate of 0.88% derived from EPA.

Data sources include:

- Estimate of Methane Emissions from the US Natural Gas Industry

Industrial Processes & Use (IPPU)

Industrial Processes

GHG emissions result from the chemical and physical transformations during manufacturing activities, such as cement production, metal processing and chemical use. Industrial process emissions were calculated using a combination of emissions data from EPA's SIT and EPA's GHGRP FLIGHT. GHGRP FLIGHT has emissions data directly from facilities while SIT estimates emissions for the entire state from national data. GHGRP only requires large facilities to report, whereas SIT would estimate emissions for the entire industrial processes sector, including from non-reporter facilities that are not required to submit data under GHGRP.

First, the industrial process (IP) Module from SIT was used to calculate emissions from the entire state for limestone and dolomite usage, soda ash, iron and steel production, and urea consumption. These state-level emissions were downscaled to each county using employment data from BLS. Secondly, Virginia and North Carolina's GHGRP FLIGHT data were compiled for the following sectors: chemicals, other, minerals, metals, and pulp and paper. Reporting facilities within the MSA were identified in the GHGRP dataset. For those facilities, the reported GHGRP subpart was used to assign emissions to the appropriate IP subsector. Emissions from facilities that only reported to Subpart C, General Stationary Fuel Combustion, were excluded as this is not relevant to the IP sector.

The FLIGHT data from reporting facilities were then combined with the SIT data to account for non-reporters for sectors that have data in both datasets. If the FLIGHT emissions value was greater than SIT's emissions value, the SIT data were not used. If scaled SIT emissions were larger, the difference between the SIT and GHGRP emissions were noted and the SIT value was used. Cement manufacturing and lime manufacturing are "all-in" sectors in GHGRP, meaning that there is no minimum threshold for reporting and all facilities must report emissions. Therefore, GHGRP data from these sectors were not combined with SIT data.

Data sources include:

- EPA SIT IP Module
- EPA GHGRP FLIGHT
- U.S. Bureau of Labor Statistics (BLS)

Product Use

Emissions from product use come from industrial products such as refrigerants in cooling systems. Product use emissions were calculated using EPA's SIT IP module. The IP Module from SIT was used to calculate emissions from the entire state for ozone depleting substances (ODS) substitutes and electric power transmission and distribution systems. These state-level emissions were then downscaled to each county using population data.

Data sources include:

- EPA SIT IP Module
- PlanRVA population data

Natural Lands

Forest Carbon Flux

Forests sequester CO_2 during photosynthesis and act as a carbon sink. If trees are removed and used elsewhere, they can be a source of emissions. The EPA SIT Land Use, Land Change and Forestry module was used to estimate carbon sequestration in forested lands in Virginia and North Carolina using the default SIT inputs for forest carbon flux. The output data from SIT were downscaled to the county level by multiplying by the ratio of forested area in the county and state.

Data sources include:

- EPA SIT Land Use Module
- National Land Cover Dataset

Wetlands

Wetlands sequester carbon in vegetation and soils through biological processes acting as a sink. Wetlands were incorporated into the inventory to supplement categories not directly represented within SIT outputs. Because SIT aggregates wetland carbon flux within the forest land category, a separate methodology was developed to explicitly account for wetland carbon stocks and fluxes in the Hampton Roads MSA. Wetland area estimates were derived from the 2018 Chesapeake Bay Program 1-meter Land Use/Land Cover dataset, which provides high-resolution delineation of wetland types across the region.

To differentiate coastal and mineral wetlands, each exhibiting distinct carbon sequestration dynamics, the U.S. Department of Agriculture (USDA) GSSURGO soils database was used to identify mineral soil regions. This classification informed the assignment of wetland-specific carbon coefficients consistent with IPCC 2006 Guidelines and the Wetlands Supplement.

County-level activity data was provided as an input to IPCC Inventory Software to apply the appropriate Tier 1 default factors for wetland carbon sequestration and emissions estimation. The software facilitated generation of total net CO_2 removals for each county within the MSA, ensuring consistency with international inventory protocols and interoperability with standard national reporting frameworks.

Data sources include:

- 2018 Chesapeake Bay Program Land Cover Dataset
- GSSURGO Soils Database
- IPCC Wetlands Chapter

Urban Trees

Urban trees act as a carbon sink by sequestering carbon through photosynthesis. Carbon sequestration from urban tree canopies was estimated using tree cover percentages and urban area estimates. The tree canopy percentage for each county was sourced from the 2021 NLCD tree canopy percentage. Urban area in square kilometers for 2018 were acquired from the Chesapeake Bay Program's 1 meter resolution land cover data settlement pixels. The urban area was then multiplied by the percentage of total tree cover for each county. Emissions were calculated by multiplying the urban tree canopy area by the average net carbon emissions per area of tree cover from the U.S. Inventory.

Data sources include:

- Urban Tree Canopy Assessment
- U.S Inventory of GHG Emissions and Sinks
- 2018 Chesapeake Bay Program Land Cover Dataset
- Urban and Rural
- National Land Cover Dataset

Landfilled Yard Trimmings and Food Scraps

GHG removals from landfilled yard trimmings and food scraps result from the long-term storage of carbon in organic materials that remain sequestered in landfill environments. SIT was used to calculate sequestration from the landfilled yard trimmings and food scraps subsector. SIT default values were used for the composition of yard trimmings, annual quantity of landfilled yard trimmings and food scraps, carbon content, dry weight to wet weight ratio, proportion of carbon from each material stored

indefinitely in landfills, and the half-life of degradable carbon in each material. The output from SIT was downscaled to the county level using population.

Data sources include:

- EPA SIT Land Use Module
- Urban and Rural

Forest Fires

Emissions from forest fires result from the combustion of carbon stored in plant and tree organic material. SIT was used to estimate emissions from forest fires, which produce CO_2, N_2O, and CH_4 emissions. SIT's default emission factors and combustion efficiencies were used. The non-CO_2 emissions from Forest Fires worksheet uses the area burned per year. The forest fire emissions were downscaled using forest fire extents from Monitoring Trends in Burn Severity (MTBS) for 2022 for each county.

Data sources include:

- EPA SIT Land Use Module
- Measuring Trends in Burn Severity dataset

Soils

Soils result in both emissions and removals from the application of synthetic fertilizers, land management practices, and changes in soil carbon stocks. SIT's Land Use, Land Use Change, and Forestry (LULUCF) module was used to estimate N_2O emissions resulting from fertilizer application to settlement soils. To calculate N_2O emissions from settlement soils, the amount of synthetic fertilizer applied was multiplied by the emission factor for direct N_2O emissions. The module also estimates agricultural soil carbon flux and includes carbon flux from aboveground biomass, belowground biomass, deadwood, and litter in cropland and grassland ecosystems. The net change in agricultural soil carbon is the change in the amount of carbon stored primarily in mineral and organic soils over time. The SIT output was downscaled to the county level using the National Land Cover Dataset. To calculate the N_2O emissions from settlement soils and agricultural soil carbon flux, the ratio of county to state developed areas were multiplied by the Virginia and North Carolina data derived from SIT. To calculate the N_2O emissions from agricultural soil carbon flux, the ratio of county to state cropland areas were multiplied by the Virginia and North Carolina data derived from SIT.

Data sources include:

- EPA SIT Land Use Module
- National Land Cover Dataset

Agriculture

N_2O from Soils

Nitrous oxide emissions from soils result from microbial processes like nitrification and denitrification. Data from SIT was used to estimate nitrous oxide emissions from fertilizer use. Nitrous oxide emissions from soils were separated into direct and indirect emissions from synthetic fertilizer and organic fertilizer (i.e., manure, activated sewage sludge, and other organic materials).

Data from SIT was scaled using the method described in EPA's Guidance for County and Regional Inventories for Agriculture and Land Management with slight variations. SIT data were pulled for the states of North Carolina and Virginia for all historic years. SIT had proxied fertilizer use from 2016 for years 2017-2024; instead, this inventory used linear interpolation to generate fertilizer use estimates from 2017-2022. Then, EPA guidance was followed to convert fertilizer years to annual years.

Fertilizer activity data were not available at the county level, and so total fertilizer application data for North Carolina and Virginia was scaled for Hampton Roads counties using USDA National Agricultural Statistical Service (NASS) data on county crop acres as a proportion of total North Carolina and Virginia crop acres.

Estimates of calendar year fertilizer consumption were generated based on EPA assumptions of percent application of various fertilizer for synthetic nitrogen, manure, activated sewage sludge, and other organic materials for North Carolina and Virginia.

Direct emissions were calculated by multiplying the consumption of fertilizer by the IPCC direct emission factor for kg N_2O/kg N. Indirect emissions were calculated by multiplying the consumption of fertilizer by the percent of total nitrogen volatilized from organic matter, the total nitrogen leached from organic matter and IPCC emission factors for volatilization of nitrous oxide and leaching of nitrous oxide.

Data sources include:

- EPA SIT Agriculture Module
- USDA NASS data
- EPA's Guidance for County and Regional Inventories for Agriculture and Land Management
- IPCC emission factors

Livestock

Emissions from livestock come from two processes: enteric fermentation, which produces CH_4 and manure management, which produces both CH_4 and N_2O. The amount of CH_4 emitted by enteric fermentation depends on the number of livestock, type of livestock (i.e., type of digestive system), and amount of feed consumed.

Manure releases CH_4 as it decomposes under anaerobic conditions and emits N_2O through nitrification and denitrification. The amount of N_2O released by manure management practices depends on the total amount of nitrogen excretion for the management system. This requires calculating the average nitrogen excretion rate per head for each livestock category as well as the fraction of annual excretion that is managed within the system.

Livestock data for cattle (dairy and beef), chickens (broilers and layers), horses, mules, goats, swine and sheep were acquired from USDA Quick Stats. Dairy and beef cattle were separated by multiplying cattle population totals by the average percent proportion of dairy to beef cattle in the states of North Carolina and Virginia. The chicken population was adjusted to an average annual population (as broilers for example typically live for 45-60 days in the U.S.) according to the IPCC population adjustment method.

Because detailed data on subspecies populations, excretion rates, average weights, etc., were not available at the state or county level, implied emission factors were used for enteric fermentation and manure management per head. EPA's State Level Disaggregates of the U.S. Greenhouse Gas Inventory were used for emission totals, dividing by the population of each animal to find overall emission factors per emission source. The livestock populations by county were multiplied by these emission factors to find total emissions for each type of livestock.

Data sources include:

- USDA Quick Stats (National Agricultural Statistics Service) data
- U.S. Inventory of GHG Emissions and Sinks
- USDA NASS data
- IPCC emission factors
- U.S. GHG Emissions and Sinks

Liming

GHG emissions from liming result from the application of limestone and dolomite to soil which release CO_2 through chemical reactions during soil pH adjustment. Liming emissions were calculated using the EPA's State Level Disaggregates inventory data for 2021 as a proxy for 2022. Total emissions from limestone and dolomite consumption in North Carolina and Virginia were divided by the IPCC emissions factor to find tons of limestone and dolomite consumed in the states. The data was then scaled to the county level using percent of state cropland as described under agricultural soils. The county-level tonnage data was then multiplied by the IPCC emissions factor to find emission totals by county.

Data sources include:

- EPA State Level Disaggregates inventory data
- IPCC emission factors

Urea

When urea-based fertilizers are applied to soil, GHGs are emitted as it breaks down in the soil. Urea emissions were calculated using the state total of urea consumption from SIT. North Carolina and Virginia's annual consumption of urea in 2022 was scaled to the county level using percent of state cropland per county. The estimated state consumption was then multiplied by the IPCC emission factor for urea fertilization to find total emissions by county.

Data sources include:

- EPA SIT Agriculture Module
- USDA Quick Stats (National Agricultural Statistics Service) data
- IPCC emission factors

Field Burning of Agricultural Residues

Emissions result from the combustion of leftover crop materials which release GHGs. The number of acres planted with crops with high rates of field burning of agricultural residues: corn, soybeans, cotton, lentils, rice, sugarcane, and wheat were acquired from USDA. This acreage data were multiplied by the residue to crop ratio, fraction residue burned, dry matter fraction, burning efficiency, combustion efficiency, and carbon content for each crop using assumptions from SIT.

Data sources include:

- EPA SIT Agriculture Module
- USDA Quick Stats (National Agricultural Statistics Service) data

Transportation

On-Road

GHG emissions from on-road transportation are due to the combustion of fossil fuels, such as gasoline and diesel, in vehicle engines and are found in vehicle exhaust. These emissions were calculated using a bottom-up approach using EPA's Motor Vehicle Emissions Simulator (MOVES5). MOVES5 accounts for on-road vehicles through categorization of fuel type, vehicle class, and model year. For each category of vehicle, MOVES provides a quantification of the population of vehicles, vehicle miles traveled, and emissions allocated by county. Default input values were used, and MOVES5 outputs were scaled using local vehicle miles traveled (VMT) data for counties that are part of Hampton Roads Transportation Planning Organization (HRTPO). To calculate emissions from electric vehicles (EVs), the energy consumption for each vehicle class from Motor Vehicle Emissions Simulator (MOVES) was multiplied by emission factors from the SRVC eGRID region.

To separate biogenic CO_2 emissions from fossil CO_2 emissions, it was assumed that gasoline contains 10% ethanol by volume and that E-85 contains 85% ethanol by volume. The volume of fuel consumed by on-road vehicles was found by dividing the gasoline and E-85 energy consumption by their energy densities, and each component fuel was multiplied by the applicable emission factor to obtain CO_2 emissions.

Data sources include:

- EPA Motor Vehicle Emissions Simulator (MOVES5)
- eGRID

Railways

Railways emit pollutants from diesel combustion in freight and passenger trains. To calculate emissions from railways, freight rail activity data came from the Bureau of Transportation Statistics (BTS) Freight Analysis Framework (FAF). FAF provides the number of ton-miles originating in and bound for a given destination. These data were allocated by county and by freight rail provider using GIS data from the BTS National Transportation Atlas Database. Railway track miles were tabulated by county and freight provider to allocate ton-miles bound for and originating in each county in the MSA. Half of the total ton-miles from the FAF are included in the inventory per guidance in the Global Protocol for Community-Scale Greenhouse Gas Inventories (GPC) protocols to avoid double counting with other jurisdictions.

Fuel usage data in ton-miles per gallon were then multiplied by the activity data to acquire fuel quantities. Fuel usage for the freight providers in the MSA, CSX, Norfolk Southern, and Genesse & Wyoming (which operates commonwealth and the Chesapeake & Albermarle railways), was provided in company sustainability reports. For smaller freight rail operating in the area (e.g., Norfolk & Portsmouth belt line and Buckingham Branch railway), the fuel quantities were then multiplied by emission factors from EPA's GHG Emission Factor Hub to determine.

For passenger rail provided by Amtrak, the number of track miles within each county by Amtrak route was calculated from GIS data from the BTS National Transportation Atlas Database. The total annual miles were calculated using the number of trips per year based on the schedule of each route. From total miles, fuel use was determined with an Amtrak-specific fuel economy factor for diesel gallon equivalent. From fuel use, emissions were generated using EPA's GHG Emission Factor Hub to determine GHG emissions.

Railroad support emissions generated within the MOVES nonroad model has been included as a part of the railways sector and is included in the railways total emissions (see nonroad MOVES methodology in the off-road section below).

Data sources include:

- U.S. DOT Freight Analysis Framework
- Bureau of Transportation Statistics (BTS) National Transportation Atlas Database (NTAB)
- Genesse & Wyoming Sustainability Report
- CSX and Norfolk Southern corporate reports
- Amtrak route information
- Association of American Railroads Freight Rail and Climate Change
- EPA GHG Emission Factor Hub

Waterborne Navigation

GHG emissions from waterborne navigation come from the combustion of fossil fuels such as diesel in recreational and commercial boats, or other waterborne vessels. Emissions from tugs, pushing barges, excursion boats, commercial fishing boats and work boats were calculated using California Air Resources Board (CARB) harbor craft emissions inventory methodology. Emissions data from the Port of Los Angeles was scaled based on waterborne cargo and trips data from the U.S. Army Corps of Engineers for Norfolk, Newport News, and the Port of Los Angeles.

Emissions associated with pleasure craft were calculated using EPA's MOVES5 tool's NONROAD module. This tool provides an estimate for population, source hours, sector, fuel type, and emissions for nonroad equipment. Emissions associated with pleasure craft were attributed to the waterborne navigation category in this inventory.

For the purposes of GHG mitigation strategies, ports are included in the industrial sector.

Data sources include:

- California Air Resources Board (CARB) Port Analysis
- Waterborne Commerce Statistics Center
- McDonough Marine Services vessel characteristics
- EPA MOVES5
- Waterborne Cargo and Trips Data Files

Aviation

Emissions from aviation result from the combustion of jet fuel in aircraft engines and from airport support equipment. To calculate aviation emissions, activity data were acquired from the Federal Aviation Administration (FAA) through The Operations Network (OPSNET). OPSNET provides the number of landings and takeoffs (LTO) from local and itinerant flights from Norfolk International Airport (ORF) and Newport News-Williamsburg International Airport (PHF). OPSNET does not provide data for small private airports, and thus LTO data for the Hampton Roads MSA is only available for ORF and PHF. Emissions from aircraft were calculated using IPCC GHG inventory guidelines for aircraft.

Emissions from aircraft support equipment were also attributed to the aviation sector. Emissions associated with aircraft support equipment were derived using EPA's MOVES NONROAD module. This tool provides an estimate for population, source hours, sector, fuel type, and emissions for nonroad equipment.

Data sources include:

- Federal Aviation Administration's Operations Network (FAA OPSNET)
- IPCC Emission factor for Average Fleet LTO operations
- EPA MOVES5

Off-Road

GHG emissions from off-road sources result from the combustion of fossil fuels in vehicles and equipment used in subsectors such as lawn and garden, construction, agriculture and industrial operations. Emissions from off-road vehicles were calculated using EPA's MOVES NONROAD module. This module accounts for vehicles based on the fuel type and sector to generate populations, source hours, energy consumption, and total annual CO_2 and CH_4. The MOVES NONROAD module does not calculate N_2O emissions and was estimated using the ratio of the CH_4 and N_2O emission factors for specific vehicle type and fuel type combinations. Values for the airport support equipment, pleasure craft, and railroad support sectors are accounted in other transportation subsectors in the inventory and not in the off-road total.

Data sources include:

- EPA MOVES5
- EPA GHG Emission Factor Hub

Waste

Disposal of Solid Waste Generated in the MSA

Emissions from solid waste are from the generation of methane as waste breaks down without the presence of oxygen in landfills. These emissions from waste generated in the MSA were calculated using the methane commitment method from the Global Protocol for Community-Scale GHG Inventories (GPC). This method calculates downstream emissions associated with solid waste sent to landfills during each inventory year. The methane commitment method takes a lifecycle approach, calculating landfill emissions based on the amount of waste disposed in a given year and assigning emissions to the year of waste generation under the assumption that the emissions will occur in future years as waste decays and produces methane.

The methane commitment estimate for solid waste sent to landfill was calculated based on the mass of solid waste sent to landfill during the inventory year, the methane generation potential of waste based on the waste composition, the fraction of methane recovered at the landfill, and the oxidation factor for the landfill. Activity data on the amount of waste disposed of in landfills in 2022 was calculated using data from a North Carolina Department of Environmental Quality (NCDEQ) Annual Waste Report for North Carolina counties. For Virginia counties, waste activity data was either acquired from Southeastern Public Service Authority of Virginia or the EPA national average per capita landfill rate was combined with population to calculate amount of waste landfilled. The methane generation potential of waste was calculated using default multiplication factors from GPC and landfill-specific factors from GHGRP FLIGHT. The methane commitment equation from GPC to was used to calculate emissions from each landfill within the MSA and these values were summed to obtain emissions for the entire MSA.

Data sources include:

- Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
- Central Virginia Waste Management Authority (CVWMA) and Virginia Peninsulas Public Service Authority (VPPSA) Solid Waste Management Plans
- Greenhouse Gas Reporting Program (GHGRP) Facility-Level Information on Greenhouse Gas Tool (FLIGHT)

- EPA Landfill Methane Outreach Program (LMOP)
- Population data provided by HRPDC
- Municipal solid waste disposal data

Biological Treatment of Waste Generated in the MSA

Biological treatment of waste creates emissions from the decomposition of organic materials during composting. Emissions from the biological treatment of waste were calculated using the amount of waste composted in the VPPSA compost facility and composting equations from GPC. The data on tonnage of compost was received via email from VPPSA. This tonnage data was multiplied by the emission factors for nitrous oxide and methane from GPC to acquire the emissions for composted waste in 2022.

Data sources include:

- Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

Incineration and Open Burning of Waste Generated in the MSA

GHG emissions from incineration and burning of waste result from the combustion of solid waste which releases carbon dioxide and other GHGs. In 2022, Hampton Roads MSA had one operating incineration facility, the Wheelabrator Portsmouth facility. Emission data from 2022 for this facility were acquired from GHGRP FLIGHT.

Data sources include:

- GHGRP FLIGHT

Wastewater Generated in the MSA

Septic system emissions account for fugitive emissions resulting from the physical setting and biologic activity during the treatment process. Wastewater emissions were calculated using the GPC equations for methane and nitrous oxide from wastewater treatment plants (WWTPs). The quantity of wastewater flowing through each WWTP, population served, nitrogen removed with sludge, total nitrogen discharged, and biological oxygen demand (BOD) from each WWTP was obtained directly from WWTPs. Two WWTPs in the MSA did not provide flow data while ten of the WWTPs did not provide BOD data; the flow rate and BOD for these facilities were estimated using a per capita flow rate and a flow-weighted average BOD using the data from all other WWTPs in the MSA.

Data sources include:

- Integrated Compliance Information System - National Pollutant Discharge Elimination System (ICIS-NPDES)
- Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
- Population data provided by HRPDC
- EPA Enforcement and Compliance History Online

GHG Business-As-Usual Projections

The 2022 GHG inventory and BAU projections establish a quantitative foundation for regional climate-action planning. The inventory defines baseline emissions, and the BAU scenario illustrates how those emissions could evolve through 2050 without additional mitigation. Together, they highlight key emission sources and growth patterns and set the basis for evaluating reduction pathways and co-benefits associated with CCAP measure implementation.

The BAU scenario projected future GHG emissions through 2050, assuming no additional mitigation actions beyond those already in place as of 2022. Each sector's emissions were modeled based on historical activity data and growth drivers such as population, employment, energy demand, and industrial output. The projections reflected expected trends under a continuation of current policies and practices. Compared to the 2022 inventory base year, the BAU projects that gross GHG emissions will decline 20% by 2035 and 41% by 2050. The largest projected reductions are from the transportation sector due to assumed increases in vehicle fuel efficiency and increased zero-emission vehicle adoption. The buildings sector also sees significant reductions due to cleaner electricity being used to power homes and businesses and improved equipment and appliance energy efficiency.

The BAU grid emissions factor used to estimate emissions associated with electricity consumed in the BAU comes from the Virginia State Climate Pollution Reduction Grant (CPRG) analysis, which modeled the Virginia Clean Economy Act in the BAU. This leads to a significant decline in the grid emissions factor by 2050, driving emission reductions under the BAU scenario. See the State's CPRG report for more information on this assumption. For North Carolina counties, emission factors were derived from EIA AEO 2023 (Table 54.13) projections.

The assumptions and methodologies used to develop BAU projections for each sector are described below.

Stationary Energy (Buildings)

Stationary energy emissions were projected using growth factors derived from regional energy consumption and population trends. Residential and commercial energy use were projected to increase proportionally with population growth, while industrial energy demand was expected to follow employment and output forecasts.

Residential Buildings

Year-over-year growth rates from AEO 2023 Table 2 for the South Atlantic region were applied to residential electricity, natural gas, fuel oil, propane, and other stationary fuel consumption from the 2022 inventory. The electricity consumption projections were multiplied by the BAU grid emission factor.

Data sources include:

- AEO 2023 Table 2

Commercial and Institutional Buildings and Facilities

Year-over-year growth rates from AEO 2023 Table 2 for the South Atlantic region were applied to residential electricity, natural gas, fuel oil, propane, and other stationary fuel consumption from the 2022 inventory. The electricity consumption projections were multiplied by the BAU grid emission factor.

Data sources include:

- AEO 2023 Table 2

Manufacturing Industries and Construction

For each county in the MSA, emissions from GHGRP-reporting facilities were held flat through 2050. Any remaining energy consumption and emissions data from SIT was projected using the year-over-year growth rates from AEO 2023 Table 2 or the SIT projection tool if the fuel was not present in AEO's projections. The electricity consumption projections were multiplied by the BAU grid emission factor.

Data sources include:

- AEO 2023 Table 2
- SIT Projection Tool

Energy Industries

Emissions from energy industries were only projected from a consumption-based perspective as described in other sections of this methodology. Generation-based emissions were not projected.

Fugitive Emissions from Oil and Natural Gas Systems

Fugitive methane emissions projections from oil and natural gas systems were calculated by multiplying the projected natural gas energy consumption from each county each year by an energy density of 41.7 MJ/kg and a leakage rate of 0.88% derived from EPA.

Data sources include:

- Estimate of Methane Emissions from the U.S. Natural Gas Industry

Industrial Processes & Product Use

Industrial Processes

BAU emissions from industrial processes were projected using EPA's State Inventory Tool (SIT) and facility-level data from EPA's GHGRP FLIGHT. The SIT Industrial Processes module was used to estimate statewide emissions from limestone and dolomite usage, soda ash consumption, iron and steel production, and urea application. These state-level totals were downscaled to counties in the MSA using BLS employment data for relevant manufacturing subsectors, consistent with the baseline inventory approach.

For sectors represented in both GHGRP and SIT, facility-level GHGRP emissions were used where available to represent large emitters, while SIT-based estimates were retained to capture emissions from smaller, non-reporting facilities. Cement and lime manufacturing are fully covered under GHGRP (Subpart H and Subpart S), and their reported emissions were used directly without adjustment. In all cases, the BAU scenario assumes IP emissions remain constant over time (2022–2050).

Data sources include:

- EPA SIT IP Module
- EPA Greenhouse Gas Reporting Program (GHGRP)
- U.S. Bureau of Labor Statistics (BLS)

Product Use

Product use emissions were estimated using EPA's SIT IP module, which includes emissions from ODS substitutes and electric power transmission and distribution systems. Statewide totals were downscaled to the county level using population data from the U.S. Census Bureau (2025).

Consistent with other sectors lacking significant expected change in baseline activity, BAU product use emissions are held constant through 2050. This approach assumes that current refrigerant use, equipment turnover rates, and grid infrastructure practices remain stable over time in the absence of additional policy or technological interventions.

Data sources include:

- EPA SIT IP Module
- U.S. Census Bureau

Natural Lands

Forest Carbon Flux

Forest carbon flux in the Hampton Roads MSA is held flat in the BAU scenario. Historical land cover trends indicated that rapid development between 2001 and 2021 was driving losses in forest area and associated carbon sequestration potential. Holding flux constant avoids overestimating sequestration and stabilizes the trajectory to reflect a steady-state stock under continued urban expansion pressure.

Urban Trees

Urban tree carbon flux is likewise held constant in the BAU scenario. Model diagnostics showed that rapid development in high-growth counties was skewing projections and producing unrealistically low sequestration rates. Fixing urban tree growth and mortality rates at baseline conditions provides a conservative estimate aligned with observed canopy stability in recent NLCD and urban forest inventory data.

Landfilled Yard Trimmings and Food Scraps

Emissions and carbon storage associated with landfilled organic materials were held flat. Existing solid waste data showed no statistically significant trend in disposal quantities or composition for yard trimmings and food scraps across the MSA. As such, a baseline assumption of constant annual flux from this category was applied.

Data sources include:

- EPA SIT Land Use Module

Wetlands

Wetland carbon flux and extent were held flat. Holding wetlands constant preserves a neutral baseline for comparative policy analysis without embedding uncertain degradation or restoration trajectories.

Soils

Soil carbon stocks were held constant in the inventory due to uncertainty in the underlying baseline data used to estimate soil carbon levels across the Hampton Roads MSA. Available datasets lack consistent temporal coverage and spatial resolution, leading to high variability in soil organic carbon (SOC) estimates derived from regional surveys and modeled products. Because soil carbon stock changes occur gradually and are sensitive to small measurement errors, incorporating uncertain baseline values could introduce bias into estimated carbon fluxes.

Agriculture

BAU emissions from the Agriculture sector are projected to increase over time, attributable to an increase in livestock and crop production. All dominant livestock populations increase over the time series (except sheep and goats) and all dominant crops increase over the time series (except barley). Total agriculture emissions are projected to increase 3.87% from 2022 to 2050. Livestock sources of emissions are projected to increase 16.02%, driven primarily by increasing swine production and subsequent manure management emissions, and increasing beef cattle production, and subsequent enteric fermentation emissions. N_2O from Soils retains the greatest share of agriculture sector emissions but remains almost constant over time with only a 1.44% increase in 2050 relative to 2022.

N_2O from Soils

N_2O from soils emissions include direct and indirect N_2O from nitrogen inputs to agricultural soils, including from synthetic and organic fertilizers, crop residues, and manure deposited by grazing animals. For North Carolina counties, activity data from N_2O from synthetic and organic fertilizers is based on 2022 data from the SIT, detailing the total synthetic fertilizer applied. For Virginia counties, activity data is based on 2022 data from the Chesapeake Assessment Scenario Tool (CAST). For N_2O from manure deposited by grazing animals, 2022 SIT data provides the kilograms of nitrogen excretion (Nex) deposited annually onto pasture, range, and paddock (PRP) per animal head.

N_2O from soils emission factors and constants are sourced from the U.S. GHG Inventory and are aligned with international IPCC guidance. For synthetic and organic fertilizers, 2022 emissions are calculated by multiplying the total amount of fertilizer applied by a direct N_2O emission factor. Indirect emissions are calculated by determining the fraction volatilized, leached, or lost via runoff using GHG inventory constants, then multiplying by an indirect emission factor. For manure deposited by grazing animals, Nex is multiplied by a direct N_2O emission factor. Indirect emissions are similarly calculated using the fraction volatilized, leached, or runoff, combined with the appropriate indirect emission factor.

N_2O from soils emissions estimates are calculated as follows: direct N_2O emissions equal the activity data (amount of input or amendment) multiplied by the direct emission factor. Indirect N_2O emissions equal the activity data multiplied by the fraction volatilized, leached, or runoff, and then by the indirect emission factor.

N_2O from soils BAU input amounts were estimated by using CAST and SIT fertilizer consumption data as surrogate data for the annual rate of change of fertilizer use. Fertilizer amounts for 2023-2050 were estimated using these rates of change from the 2022 values developed using the methods described above. Emissions were estimated based on 2022 values as estimated per the methods described above.

Data sources include:

- EPA SIT Agriculture Module
- CAST Tool
- IPCC emission factors

Livestock

Livestock emissions sources include CH_4 from enteric fermentation and manure management, and N_2O from manure management. Activity data is sourced from CAST and USDA NASS QuickStats, and emission factors from the U.S. GHG Inventory's state specific, weighted species emission factors. Emissions estimates are calculated by multiplying the emission factor (emissions per livestock head per year, for each given emissions source) by the livestock's population.

Population rates of change were based on USDA 2025 Baseline Projections. Livestock populations from 2023-2050 were estimated based on 2022 values, using the USDA's projected rates of change.

Data sources include:

- USDA Quick Stats (National Agricultural Statistics Service) data
- CAST Tool
- USDA Baseline Projections

Liming and Urea

Liming and urea utilize data from SIT for 2022 and use the same surrogate data method as described above for N_2O from soils. Activity data is multiplied by the emission factor per unit of limestone, dolomite, or urea applied to derive emissions estimates.

For liming and urea, BAU input amounts were estimated by using national average historical data from SIT as surrogate data for the annual rate of change of fertilizer use. Amendment amounts for 2023-2050 were estimated using these rates of change from 2022 values developed using the methods described above. Emissions were estimated based on 2022 values as estimated per the methods described above.

Data sources include:

- EPA SIT Agriculture Module
- IPCC emission factors

Field Burning of Agricultural Residues (FBAR)

FBAR emissions were estimated based on 2022 corn, soybeans, and wheat yield data (USDA NASS), and burning constants and parameters from SIT. Emissions estimates for crop residue burning are calculated using specific formulas for CH_4 and N_2O. CH_4 emissions are determined by multiplying the crop yield by the residue-to-crop ratio, the fraction of residue burned, the fraction of dry matter, the carbon content, and the conversion factor from carbon to methane. Similarly, N_2O emissions are estimated by multiplying the crop yield by the residue-to-crop ratio, the fraction of residue burned, the fraction of dry matter, nitrogen content, and the conversion factor from nitrogen to nitrous oxide.

For BAU projections, FBAR was estimated by determining a historical rate of change of wheat yield from USDA-NASS QuickStats data. Annual production was estimated from 2023-2050 using this rate of change applied to 2022 values.

Data sources include:

- USDA Quick Stats (National Agricultural Statistics Service) data

Transportation

On-Road

VMT, vehicle population, energy consumption, and emissions were projected using EPA Motor Vehicle Emissions Simulator (MOVES5) model. Default input values were used, and MOVES5 outputs were scaled using local VMT data for counties that are part of HRTPO. Scope 1 emissions projections for all counties were obtained between 2022 and 2050 at five-year increments. Scope 2 emissions from electricity consumption were found by multiplying the resulting electricity consumption by the BAU grid emission factor. MOVES5 projections include the impacts of EPA's Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles and the Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3. All zero-emission vehicles were modeled to be battery electric.

Data sources include:

- EPA MOVES5

Railways

Year-over-year growth rates from AEO 2023 Table 7 for energy use by passenger and freight rail were applied to passenger and freight rail emissions, respectively. Railroad emissions from MOVES5 were projected using MOVES5 NONROAD results.

Data sources include:

- EPA MOVES5
- AEO 2023 Table 7

Waterborne Navigation

Year-over-year growth rates from AEO 2023 Table 7 for energy use by domestic and international shipping were applied to inventory-year port craft emissions. Pleasure craft emissions from MOVES5 were projected using MOVES5 NONROAD results.

Data sources include:

- EPA MOVES5
- AEO 2023 Table 7

Aviation

Year-over-year growth rates from AEO 2023 Table 7 for energy use by aircraft were applied to inventory-year port craft emissions. Airport support emissions from MOVES5 were projected using MOVES5 NONROAD results.

Data sources include:

- EPA MOVES5
- AEO 2023 Table 7

Off-Road

Off-road emissions were projected using MOVES5 NONROAD results.

Data sources include:

- EPA MOVES5

Waste

Disposal of Solid Waste Generated in the MSA

The solid waste emissions from 2022 were projected to 2050 using a population growth factor based on U.S. Census population data.

Data sources include:

- U.S. Census Population Data

Biological Treatment of Waste Generated in the MSA

The biological treatment of waste emissions from 2022 were projected to 2050 using a population growth factor based on U.S. Census population data.

Data sources include:

- U.S. Census Population Data

Incineration and Open Burning of Waste Generated in the MSA

The incineration emissions from 2022 were projected to 2050 using a population growth factor based on U.S. Census population data.

Data sources include:

- U.S. Census Population Data

Wastewater Generated in the MSA

The wastewater emissions from 2022 were projected to 2050 using a population growth factor based on U.S. Census population data.

Data sources include:

- U.S. Census Population Data

GHG Reduction Measure Quantification

Approach Overview

This section summarizes the methods used for calculating GHG emission reductions and costs from measures included in the CCAP, building from the BAU projections. The methods outline a "what would it take" approach to reach net zero GHG emissions by 2050 and include aggressive, but feasible, strategies and assumptions. In some instances, existing modeling efforts were used. The sections below detail the modeling approaches and assumptions used for each sector and measure to assess the potential GHG reductions and costs for the net zero CCAP Implementation Scenario.

The analysis was guided by several cross-cutting assumptions applied consistently across all measures:

- **Technology and Market Adoption.** Gradual but widespread adoption of mature and emerging technologies was assumed, with linear or logistic adoption curves extending to 2050. Technology penetration rates reflected published projections from the Department of Energy (DOE), EPA, and National Renewable Energy Laboratory (NREL).
- **Policy Continuity and Investment.** The modeling assumed continued policy support at state and federal levels, including implementation of the Virginia Clean Economy Act (VCEA) and ongoing infrastructure funding through existing climate and energy programs.

The cost assessment is designed to incorporate the following key elements to quantify total implementation costs tied to a measure, with the perspective of a societal impact, and relied on any public resources available.

- **Capital costs** associated with the upfront investment costs to implement a measure, including investments in infrastructure, equipment, or technology.
- **Operational costs** linked to the execution of each measure, including recurring costs required to operate and maintain the measure, as well as any changes in ongoing expenditures or savings resulting from its implementation, such as variations in fuel and electricity use, or incentives deployed to support the measure.

Further details on the methodology and any sector-specific or measure-specific constraints are provided in the sections below. Results are presented to capture the annual incremental costs (or savings) of implementing each measure over the 2025-2050 timeline as compared to a reference case scenario. Note that all estimates are shown in 2025 real dollars.

Table B1 summarizes cumulative emission reductions and costs modeled across each sector, with negative values shown in parentheses. Table B2 lists all GHG reduction measures included in the CCAP.

Table B1: Cumulative Emission Reductions and Costs by Sector

	Emission Reductions ($MMTCO_2e$)		Costs (Million $2025)	
Sector	**2025-2030**	**2025-2050**	**2025-2030**	**2025-2050**
Agriculture and Natural Lands	0.18	26.89	$13.83	$161.11
Transportation	1.13	29.58	$3,300.25	$48,612.65
Buildings	2.91	44.22	[1]$(47.63)	[1]$(1,686.17)
Energy Supply	0.68	4.56	$127.41	$(477.50)

	Emission Reductions ($MMTCO_2e$)		Costs (Million $2025)	
Sector	2025-2030	2025-2050	2025-2030	2025-2050
IPPU and Ports	0.42	6.06	[2]$163.68	[2]$774.37
Waste and Wastewater	0.01	1.48	$3.10	$800.53

[1] Buildings sector costs include residential, commercial, and industrial buildings. Costs for IP decarbonization (Measure I1) are included here as well due to bundled cost quantification for industrial building and IP costs.

[2] Industrial sector costs exclude Measure I1, as costs from IP decarbonization are reported under the buildings sector totals.

Table B2: GHG Reduction Measures

#	Sector	Measure
NWL1	Agriculture and Natural Lands	Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands
NWL2	Agriculture and Natural Lands	Support local food production, urban agriculture, and farm-to-school initiatives
NWL3	Agriculture and Natural Lands	Increase soil conservation practices and methane reduction on urban and agricultural lands
T1	Transportation	Increase the adoption of low and zero-emission vehicles (LEV/ZEV) by developing education, outreach, and planning materials to localities for purchasing and maintaining ZEVs and develop a fueling infrastructure deployment strategy
T2	Transportation	Reduce vehicle miles traveled and support alternative modes of transportation through bike/pedestrian infrastructure investments
B1	Buildings	Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for local government and school buildings
B2	Buildings	Reduce energy consumption and increase building efficiency through programs to support, incentivize, and install weatherization and electrification measures in residential buildings
B3	Buildings	For commercial and industrial buildings, increase energy efficiency through financial incentives and educational outreach programs and strongly encourage the design, building, and operation of buildings above current required code
E1	Energy Supply	Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub
E2	Energy Supply	Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency
I1	Industry	Support emissions reductions from industrial processes
I2	Industry	Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes
W1	Waste and Wastewater	Decrease the amount of waste sent to landfills
W2	Waste and Wastewater	Support efficiency upgrades at wastewater treatment plants (WWTPs)

GHG Goals

This plan sets near-term and long-term GHG reduction goals:

- 2035: 20% below 2022 levels (gross)
- 2050: net zero GHG emissions

The near-term goal is set based on the BAU emission projections, which reflect the continued successful implementation of existing policies and programs as well as a continuation of current market trends. The long-term goal of net zero emissions by 2050 is aspirational and used to provide information on what it would take to transform the region over the next 25 years.

The modeled scenario for the CCAP surpasses the near-term goal and shows a path to net zero emissions. The Net Zero Scenario reduces gross GHG emissions 36% from 2022 levels by 2035 and achieves a 92% reduction in net emissions by 2050.

Results Overview

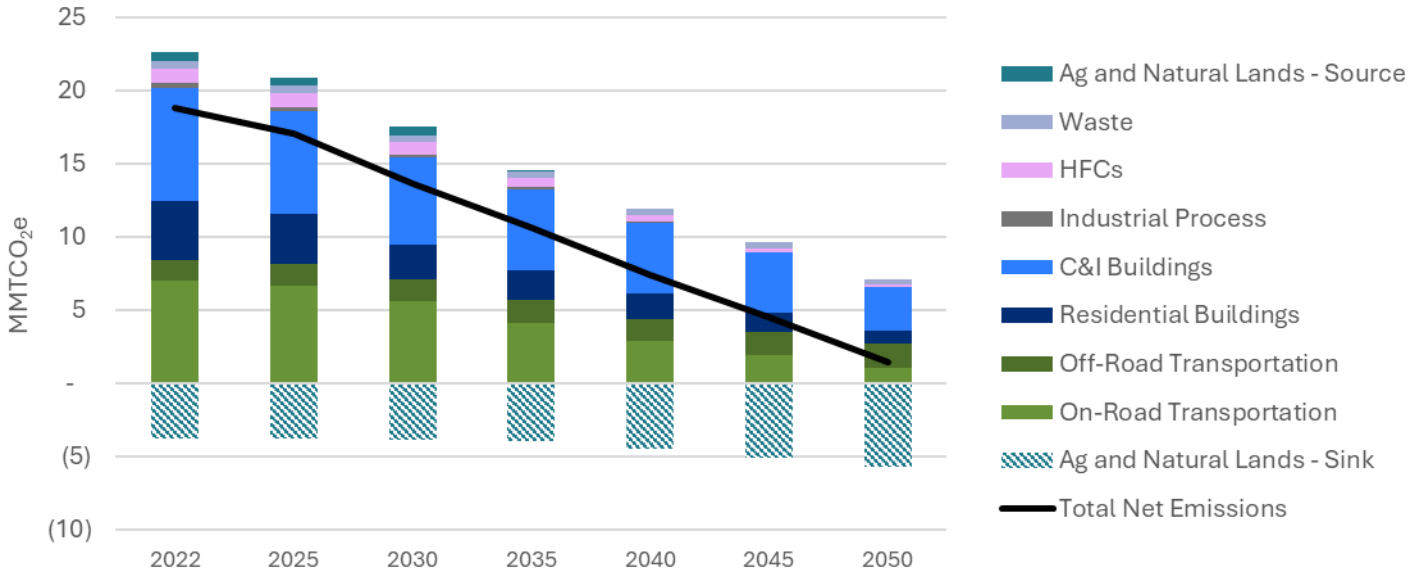
The modeling integrated all sectoral measures into a single, internally consistent Net Zero Scenario framework. Each measure's quantified reductions were applied relative to the BAU trajectory. The results underscored several important insights for achieving a net zero emissions future:

- **Electrification and renewable energy deployment** are essential near-term drivers of decarbonization, offering both direct emissions reductions and indirect benefits for other sectors.
- **Carbon sequestration and methane management** provide critical balancing measures to address residual emissions and enhance natural climate solutions.
- **Efficiency and conservation** deliver high cost-effectiveness and co-benefits such as lower energy bills and improved air quality.
- **Policy stability, investment coordination, and data transparency** are vital for sustaining progress and tracking results through 2050.

The quantified results provide a robust analytical foundation for regional climate action planning. They demonstrate that the Hampton Roads MSA can achieve deep decarbonization through a diverse portfolio of measures combining technology deployment, behavioral change, and natural systems management. While the modeled Net Zero Pathway represents a technically feasible scenario, achieving it will depend on sustained collaboration across jurisdictions, agencies, utilities, and community partners.

Figure B1 shows the region's GHG emission projections by sector. **Compared to the 2022 inventory base year, the pathway achieves about 92% reduction in net emissions by 2050**, with around 1.4 $MMTCO_2e$ of net GHG emissions remaining in 2050. Additional activities will be needed to address the remaining emissions, potentially relying on emerging technologies or carbon capture.

Figure B1: Hampton Roads MSA GHG Emissions by Sector: Net Zero Pathway Scenario

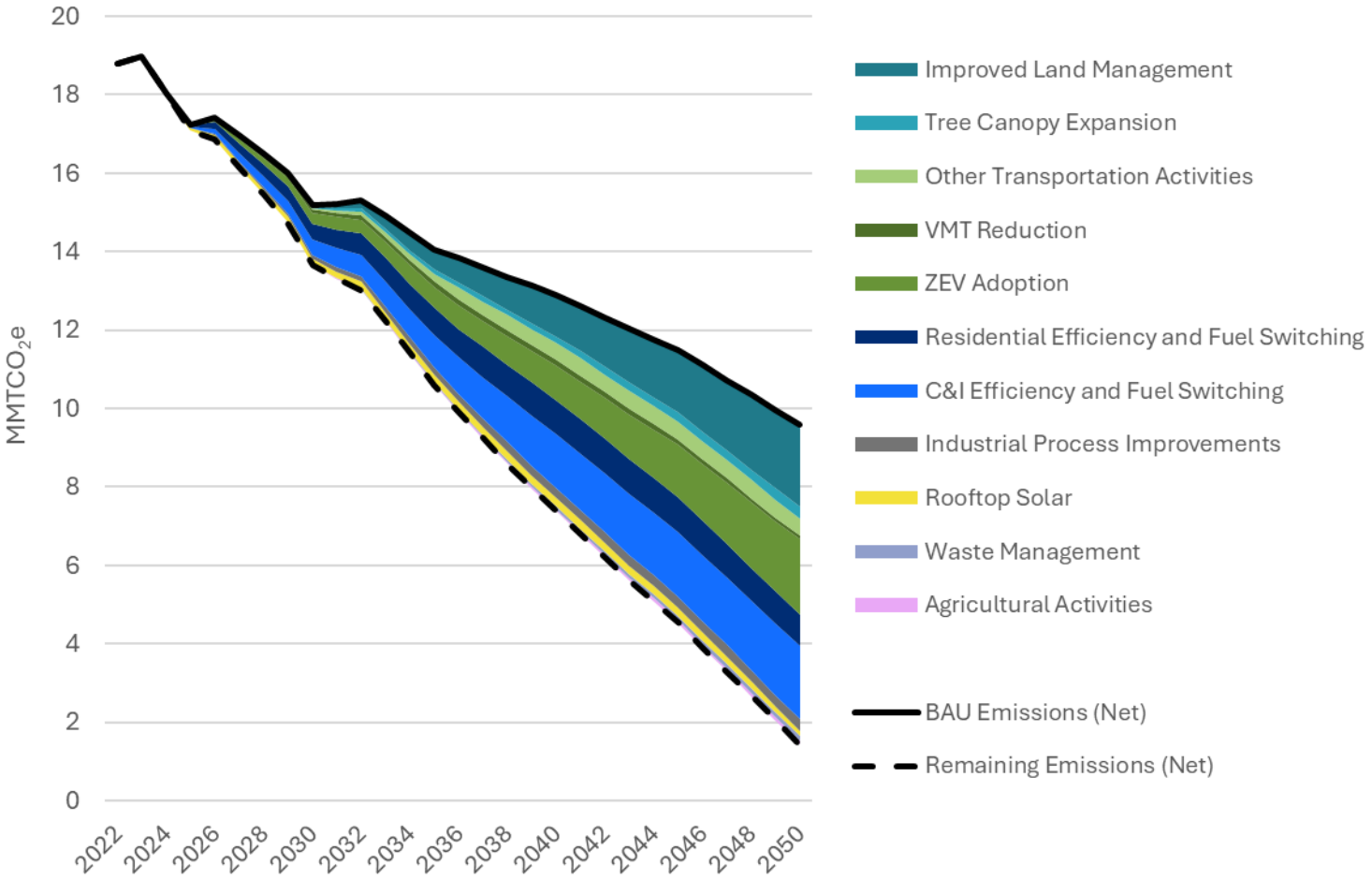


To present GHG reductions by measure, a "wedge chart" may be used in planning efforts to illustrate how different climate mitigation strategies impact GHG emissions over time. In Figure B2, each "wedge" represents a mitigation strategy (e.g., ZEV adoption, urban tree canopy expansion, etc.) tied to the GHG measures listed in Table B2. Some measures have been aggregated into wedges to simplify the chart. The chart shows the cumulative reductions from the various measures compared to the BAU Scenario.

The top line of the chart shows the BAU emissions and the bottom line shows the emissions under the Net Zero Scenario. The wedges in between represent the various ways to close the gap between the BAU and Net Zero Scenarios. The bigger the wedge, the bigger the impact of that measure. Taken together, the wedges are a visual tool to help understand how the multiple measures come together to achieve the plan's goal of net zero GHG emissions by 2050.

In order of magnitude, the agriculture and natural lands, transportation, and residential and commercial buildings sectors are the top three drivers of emission reductions, followed by industry and waste. The state's targets for a net zero electric power sector are a key enabling strategy to support end-use electrification across the transportation, buildings, and industrial sectors without shifting emissions from those sectors to the power sector.

Figure B2: Net Zero Scenario: GHG Emission Reductions from Each Measure



Under the Net Zero Scenario, each sector sees substantial reductions in GHG emissions from 2022 to 2050:

- 62% decline in C&I building sector emissions, inclusive of efficiency, electrification, and use of RNG
- 80% decline in residential buildings, inclusive of efficiency, electrification, and use of RNG
- 93% reduction in industrial process emissions
- 85% reduction in on-road transportation emissions inclusive of VMT reduction, ZEVs, and the use of RD
- 25% reduction in off-road transportation emissions, driven by reductions in the aviation sector
- 22% reduction in emissions from waste, inclusive of solid waste diversion and improvements at WWTPs
- 45% reduction in agriculture emissions, inclusive of feed management and cover crop adoption practices
- A 70% increase in carbon sequestration on natural lands

Agriculture and Natural Lands

This sector evaluated opportunities to reduce emissions and enhance carbon sequestration through sustainable agricultural practices, soil carbon management, and restoration and protection of natural and working lands. Measures in this sector addressed both direct emission sources (such as fertilizer use and livestock methane) and carbon sinks (such as forest and wetland restoration). Given the region's extensive natural assets, the MSA has significant potential to increase carbon sequestration by preserving, restoring, and enhancing the land cover it already maintains, which is what the first measure

focuses on. The second and third measures decrease emissions by supporting local food production and promoting soil conservation practices and methane reduction on urban and agricultural lands. Table B3 shows the cumulative emission reductions modeled for each measure. Together, these measures are projected to decrease emissions by 26.89 $MMTCO_2e$ from 2025 through 2050.

Table B3: Summary of Agriculture and Natural Lands Sector CCAP Measure GHG Reductions ($MMTCO_2e$)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands	0.12	25.74
Support local food production, urban agriculture, and farm-to-school initiatives	NE	NE
Increase soil conservation practices and methane reduction on urban and agricultural lands.	0.05	1.15

NWL1: Increase opportunities for carbon sequestration through tree planting, protecting, and restoring high-carbon coastal habitats, wetlands, and forest lands

This measure quantifies increased carbon sequestration from expanding regional tree canopy and increasing the use of improved land management practices on forested lands and wetlands. Modeling approaches for each component are discussed below.

GHG Approach

Tree Canopy

Given the region's existing urban development and tree cover, there is significant potential to enhance carbon sequestration by increasing tree canopy coverage within urban areas. The measure was estimated by comparing the baseline tree canopy area with a scenario that achieves locality-specific or regional canopy goals by 2050.

Baseline tree canopy area was calculated using the Chesapeake Bay Program's 1-meter resolution land cover dataset. Sequestration rates from tree cover were determined using the 2023 U.S. GHG Inventory Report. Tree cover pixels were identified within 2020 Census-defined urban areas for each county in the MSA using ArcGIS. The baseline represents the current extent of urban tree canopy.

For the measure scenario, a 2050 tree canopy goal of 50% was assumed for the region unless a locality had a baseline above 50%, in which case a 60% tree canopy goal was used. The target canopy area was calculated based on these goals. The increase in canopy area was then used to estimate additional carbon sequestration.

Data sources include:

- Chesapeake Bay Program 1m Land Cover Dataset was used to calculate baseline tree canopy area across the MSA, identifying tree canopy pixels within 2020 Census-defined urban areas.
- ArcGIS was used to intersect tree canopy data with urban boundaries and calculate baseline canopy extent.

Limitations include:

- Assumes all urban areas can support increased canopy, which may not reflect on-the-ground constraints (e.g., impervious surfaces, land use conflicts).
- Sequestration rates are generalized and may not reflect species-specific or site-specific variability.
- Does not account for potential canopy loss due to development, pests, or climate impacts.
- Assumes linear growth in canopy area, which may not reflect actual implementation timelines.

Data sources include:

- U.S. Census Bureau Urban and Rural Areas Census data for 2010 and 2020. Urban area boundary polygons were used to calculate the extent of tree cover located within urban areas.
- Chesapeake Bay Program 1m Land Cover Dataset was used to calculate baseline tree canopy area across the MSA, identifying tree canopy pixels within 2020 Census defined urban areas.
- Carbon sequestration potential rates of settlement trees in Virginia are determined using the 2023 US GHG Inventory Report table 6-125 *"Estimated Annual Carbon Sequestration, Tree Cover, and Annual Carbon Sequestration per Area of Tree Cover for settlement areas in the United States by State and the District of Columbia"*.

Improved Land Management

The analysis estimated additional carbon sequestration resulting from new restoration and protection activities compared to the BAU scenario. Annual carbon uptake rates were applied to restored or protected acres, and cumulative carbon storage was summed through 2050.

The baseline total ecosystem carbon stock stored within the 5 key land cover types across the MSA was calculated including deciduous, mixed, and evergreen forests, and wetlands. For this analysis, above-ground biomass, below-ground biomass, and soil organic carbon stocks were calculated for each land cover type from 1990 to 2022, following the standard accounting practice per the IPCC methodology based on the latest data available. Above-ground biomass measurements were converted into carbon estimates from ratios taken from literature. The ratio of above-ground to below-ground biomass was also taken from literature and converted into carbon as previously done for above-ground biomass.

After finding the baseline total carbon stock in each land cover class, the improved land management carbon stock was modeled assuming 20% of each land cover type would be converted to an improved management category. A linear trend was used from the start year of 2030 to the assumed maximum in 2050, and the sequestration value in 2050 acts as a new baseline sequestration for the MSA. The improved land management factors are assumed to be 1.3 which is pulled from the IPCC 2006 guidance for grasslands. The factor represents an improvement factor which is a very general estimation of the impact of improving land management on these lands' carbon stocks, and it is also assumed to be the same amount for each land cover type, which may not capture the full picture of the effect of improved land management in the specific land cover classes. Literature review can be conducted in the future for more specific improvement factors.

The assumed turnover reached in 2050 was found by taking the total carbon stock baseline in 2022 and multiplying the percentage of the baseline stock turned over into the managed class by 1.3. The increased sequestration is calculated as the difference between the baseline and improved land management carbon stocks.

Key assumptions include:

- Biomass to carbon ratio was taken from IPCC 2006 guidance for grasslands of 0.47. The ratio of 0.50 was taken for both forests and wetlands from the U.S. Forest Service (USFS) and USDA, respectively.
- Above to below-ground biomass ratios (root to shoot ratios) were taken from the IPCC guidance for all land cover types. The mixed forest land cover type was assumed to be the average ratio of deciduous and evergreen.

- The turnover assumed was 20% of all land cover types modeled would be converted to the improved management category. A linear trend was assumed from the start year to the beginning of the theoretical maximum in 2050.
- Assumed 1.3 improved land management factor applied to all land cover types.
- No significant leakage or loss of restored acreage occurred within the modeling period.
- Sequestration rates remained constant over time, and benefits were reported through 2050.

Limitations include:

- It is assumed that all area of forests and wetlands will remain constant due to maximally effective conservation measures. In practice, development and land conversion will lead to loss of certain land cover types over time, which may reduce carbon sequestration and limit the overall value of carbon stocks in the region by 2050.
- Wetland losses due to sea level rise are not incorporated into the current mitigation modeling framework, but they represent a critical factor for long-term land use and ecosystem stability in the region. These trends should be monitored, as the large-scale inundation of wetlands threatens natural carbon storage, habitat, and flood protection functions. Given the scale of the projected losses, adaptation and resilience strategies are needed to maintain the ecological viability of Hampton Roads under rising seas.
- It is assumed that all areas are available for receipt of improved land management practices.
- The 1.3 improvement factor is a simple estimate and does not differentiate by improvement practice.
- Variability in site-specific carbon accumulation rates due to species, soil type, and hydrology.
- Exclusion of potential future disturbances (e.g., storms, sea-level rise) that could release stored carbon.

Data sources include:

- National Land Cover Dataset (NLCD) to estimate land cover data
- USDA Forest Biomass across the Lower 48 states and Alaska to approximate forest biomass
- Gridded Soil Survey Geographic (gSSURGO) Database to evaluate soil carbon stock

Cost Approach

Tree Canopy

Costs were estimated by using the Chesapeake Assessment Scenario Tool's (CAST) cost profiles dataset for Virginia. The dataset provides default unit cost estimates for each state within the Chesapeake Bay Watershed and reflects expenses incurred across both public and private entities. The dataset does not include the cost of technical assistance. The urban tree expansion measure costs include tree planting on developed lands. Table B4 presents costs for both tree planting and improved land management.

Table B4: Measure NWL1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	1.43	2.11	1.86	1.65	1.46	41.59
Tree Planting	-	1.43	1.27	1.12	0.99	0.87	26.75
Improved Land Management	-	-	0.84	0.74	0.66	0.58	14.84
Operational Costs	-	-	0.74	0.65	0.58	0.51	12.99
Improved Land Management	-	-	0.74	0.65	0.58	0.51	12.99
Total Costs	**-**	**2.87**	**4.95**	**4.38**	**3.87**	**3.42**	**54.59**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $54.59

Cost data sources include:

- CAST - Cost Profiles

Improved Land Management

Costs were estimated using the CAST cost profiles dataset for Virginia and North Carolina. The dataset provides default unit cost estimates for each state within the Chesapeake Bay Watershed and reflects expenses incurred across both public and private entities. The dataset does not include the cost of technical assistance. The land management category was divided into two cost estimates: forest management and wetlands management. For forests, the costs calculated include forest harvesting practices and agriculture and developed forest buffers. For wetlands, costs include both wetland preservation and enhancement. Cost results are presented in Table B4.

Cost data sources include:

- CAST - Cost Profiles

NWL 2: Support local food production, urban agriculture, and farm-to-school initiatives

GHG Approach

Emission reductions from this measure were not quantified due to lack of existing data on local food production and consumption in the MSA. However, qualitative evidence suggests several meaningful pathways through which this measure can reduce emissions:

- Local food production and farm-to-school initiatives can reduce GHG emissions primarily by shortening food supply chains, lowering the distance food travels from farm to plate (“food miles”), and reducing reliance on energy-intensive transportation, refrigeration, and packaging associated with conventional, long-distance food systems. Sourcing produce locally and seasonally typically decreases fuel and energy use per unit of food delivered.
- Urban agriculture further contributes to emissions reduction through reuse of organic waste and composting, which lowers methane emissions from landfills, and by reducing fertilizer and irrigation inputs when regenerative or closed loop growing systems are used. In addition, urban green spaces created by gardens and farms enhance local vegetation cover, providing modest carbon sequestration and reducing urban heat island effects.
- Farm-to-school programs can also indirectly reduce emissions by cutting food waste in cafeterias through increased student engagement with fresh, local foods and composting initiatives. Reducing food waste prevents methane formation from organic decomposition and decreases the need for upstream agricultural production.

Data sources include:

- USDA Climate Hubs
- Elahi Mirza, et al, 2025. “Urban agriculture and sustainability: A systematic review and thematic trends”

Cost Approach

Costs from this measure were not quantified.

NWL 3: Increase soil conservation practices and methane reduction on urban and agricultural lands.

Three land use categories were modeled to estimate potential GHG emission reductions from this measure: cover crop adoption, nitrification inhibitor use, and feed additives. These practices can enhance soil health and water retention while sequestering atmospheric carbon dioxide in soils. Methodologies used for each category are discussed below.

GHG Approach

Cover Crops

Cover crops are plants grown primarily to enhance soil health, reduce erosion, lower GHG emissions, and increase carbon sequestration. They also affect soil nitrous oxide (N_2O) emissions by enabling more plant uptake of nitrogen in the soil, reducing soil nitrogen available for nitrification and denitrification processes that result in nitrous oxide. As a key sustainable agriculture practice, they improve soil fertility and structure, contributing to better crop yields and reduced environmental impact. By incorporating the GHG emissions impacts of projected cover crop adoption, this measure provides a scalable and viable agricultural strategy for reducing emissions. The Mid-Atlantic region's long-standing engagement in cover cropping, particularly in Maryland, demonstrates its feasibility, offering an effective pathway to lower agricultural-sector emissions through carbon sequestration and reduced N_2O emissions.

Annual GHG emissions reduction impacts from increased cover crop adoption were estimated by comparing BAU emissions with the mitigation scenario assuming a 4% increase in adoption area annually, ramping up from 14% to a maximum of 100%.

Current cover cropping applicable acres were estimated based on the annual harvested area (acres) of field crops and vegetables in 2022 based on USDA NASS datasets. Future harvested areas were projected using observed rates of change. The BAU scenario assumes cover crop adoption remains constant at the 2017 level of 14%, meaning 14% of eligible acres continue using cover crops, sourced from 2021 USDA ERS data for North Carolina and Virgina's percent of harvested cropland.

Emissions calculations incorporate soil carbon sequestration ($MTCO_2e$) and reductions in N_2O emissions from decreased nitrogen fertilizer application. Fossil fuel emissions from agricultural equipment used for planting and maintaining cover crops were also factored into the analysis. The total emissions impact was determined by comparing GHG levels in each modeled year under the BAU scenario (no change in cover crop adoption) and the mitigation scenario through 2050.

Key assumptions include:

- Current adoption of cover crops on 14% of applicable crop acres in region based on USDA ERS Cover Crops Report[3] data for North Carolina and Virgina.
- Applicable crop acres assumed to exclude pasture as they are not generally planted annually.
- Maximum adoption assumed to be 100% reached in 2047.
- Utilize Soil Carbon Sequestration and N_2O Reduction Factor ($MTCO_2e$) from USDA Marginal Abatement Cost Curve (MACC) Report.
- Additional fuel use is 0.92 gallons per acre for planting and cultivating activities, which results in 9.7 kgs CO_2e per cover crop acre emitted from fuel use based on EPA GHG Emission Factor Hub emission data. A scheduled phase in of 100% renewable diesel (RD) by 2050 was implemented which partially offset fuel use emissions.

Limitations include:

- Assumptions and Simplifications: Soil carbon sequestration and N_2O reduction emission factors for the Mid-Atlantic region were derived from published USDA reports on cover cropping systems and feasibility. The modeling assumes that 75% of cover crops are nonlegume species, while 25% are legumes—an oversimplification of the MSA's cover cropping landscape, yet broadly representative of U.S. and regional adoption practices. Sequestration depends on the rate of adoption and assumes all acres planted that are not pastureland are available for cover cropping in any given year.
- Cover Crop Adoption Sensitivity to External Factors: Future cover crop adoption rates may fluctuate based on policy incentives and agricultural market dynamics. The ten-year harvested acreage rate of change from USDA NASS was chosen as the most representative of future trends, reflecting expected declines due to increasing urbanization. These projections align with USDA Baseline Projections estimates for national crop area changes.
- Weather Dependence: sequestration depends on weather in any given year. For example, if there is limited precipitation due to drought, crops will not grow, and SOC will not be sequestered. There may be increasing droughts and other relevant weather events due to climate change in the future. Heavy precipitation events will spike N_2O emissions which would negate some of the net sequestration.

Data sources include:

- USDA NASS Quick Stats
- Cover Crop Trends, Programs, and Practices in the United States, USDA ERS
- ARMS Farm Financial and Crop Production Practices - Tailored Reports: Crop Production Practices
- USDA Marginal Abatement Cost Curve Estimate Methodology Report
- EPA Emission Factors for Greenhouse Gas Inventories
- DOE Alternative Fuels Data Center: Renewable Diesel

Nitrification Inhibitors

Nitrification Inhibitors (NI) are chemical compounds that inhibit the nitrification process, which can prolong the retention time of nitrogen (N) in the soil. This mechanism increases nitrogen use efficiency (NUE), reducing N losses and GHG emissions. This category supports agricultural GHG emissions reduction by enhancing NUE, reducing nitrogen fertilizer inputs, and subsequent N_2O emissions, which informs broader agricultural emissions reduction efforts within the CCAP.

Annual GHG emissions reduction impacts from increased NI adoption were estimated by comparing BAU emissions with the mitigation scenario assuming a 4% increase in adoption area annually until a maximum adoption rate of 80% is reached. The measure was applied to soybeans, corn, and wheat crops and used national crop specific adoption rates based on USDA data were assumed for 2025.

For direct and indirect emissions, the mitigation scenario projecting annual MT nitrogen from synthetic fertilizer applied was multiplied by the increasing annual proportion of fertilizer applied with NI and a NI reduction factor. This proportion of total emissions was reduced by 10% to accommodate an assumed 10% increase in NUE. This was added to the remaining proportion of N_2O emissions from N fertilizer that is applied without NIs. This was then compared to the BAU scenario (no increasing adoption) estimate and the difference between the BAU scenario and the mitigation scenario (emissions avoided that would otherwise occur) was applied to the agricultural soils category of the BAU.

Crop planted areas for corn, soybeans, and wheat were projected using historical production data from USDA National Agriculture Statistics Services (NASS). Average annual rates of change in production were derived from USDA Baseline Projections which account for market trends, trade and other demand shifts, and production trends. National averages for the percentage of acres receiving N fertilizer were used to isolate applicable acres. Current adoption rates of NIs were established using data from the USDA Agricultural Resource Management Survey (ARMS).

Key assumptions include:

- National average crop-specific fertilizer application (lbs/acre) rate utilized in place of state specific values as state level rates were not available.
- Assumed percent reduction in N_2O from NI application for each applicable crop based on USDA MACC Report.
- Reduction in total N inputs of 10% due to enhanced NUE based on USDA MACC Report.
- Current adoption of NI estimated based on USDA ERS report: Cover Crop Trends, Programs, and Practices in the United States (2021).
- Increased adoption of NI over time: Maximum adoption reaches 80% for corn in 2042 and for wheat and soybeans in 2045.

Limitations include:

- NI adoption rates: Current NI adoption rates were estimated USDA National data, which may not fully capture all NI applications in the Hampton Roads region. Crop planted acreage projections assume a gradual decline over time, reflecting urbanization trends but not accounting for potential shifts in agricultural practices.

Data sources

- USDA NASS Quick Stats
- Fertilizer Use and Price Economic Research Service
- USDA National Baseline Projections, 2024-2034
- ARMS Farm Financial and Crop Production Practices - Tailored Reports: Crop Production Practices
- USDA Marginal Abatement Cost Curve Estimate Methodology Report
- IPCC 2019 Refinement, Chapter 11: N2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application
- Cover Crop Trends, Programs, and Practices in the United States, USDA ERS
- EPA Emission Factors for Greenhouse Gas Inventories
- DOE Alternative Fuels Data Center: Renewable Diesel

Feed Additives

This category involves the use of feed additives to reduce enteric methane emissions from beef and dairy cattle. These additives inhibit microbial processes in the rumen that produce methane, thereby lowering GHG emissions from livestock. The inclusion of this category targets enteric fermentation, a significant source of agricultural GHG emissions, by leveraging scientifically supported, feed-based emissions reduction strategies. This quantification provides a data-driven projection of emissions reductions achievable through phased adoption of Monensin (2026-2035) and 3-Nitrooxypropanol (3-NOP) (2036-2050), based on livestock population trends and additive efficacy.

To estimate the GHG emissions reduction potential of feed additives in livestock production, baseline population data for beef forage cattle, beef feedlot cattle, and dairy cows were pulled from the CAST. Data were pulled for the relevant counties from the "Base Conditions Report" report type and "2023 Progress" scenario. The per head emission factor is an important driver for emissions reductions estimates and so beef cattle population data was further disaggregated for mitigation modeling into the feedlot and foraging proportion of cattle (both groups excluding calves). The feedlot beef cattle population was calculated by multiplying the population of beef cattle in Hampton Roads by the national proportion of feedlot cattle to the total beef cattle population. The foraging beef cattle population was calculated by multiplying the population of beef cattle in Hampton Roads by national proportion of bulls to the total beef cattle population. Future livestock population estimates were projected using national average annual growth rates from the USDA Baseline Projections, which account for market trends, trade and other demand shifts, and production trends.

To calculate enteric fermentation emissions, the applicable population was multiplied by the proportion receiving either Monensin or 3-NOP depending on the ear, and the respective feed additive emission reduction factor. This was added to the remaining proportion of the applicable population that did not receive any mitigation feed additive, which was multiplied by the standard per head emission factor. Phased adoption of Monensin was assumed from 2026-2035, ramping up from 3% to 30%. Due to current cost and consumer perception barriers, the adoption of 3-NOP was not assumed to start until 2035, ramping up from 5% to 100%. Adoption of the two strategies is phasic as there is insufficient scientific evidence to suggest that impacts on enteric fermentation emissions would be additive if implemented at the same time (despite that science may later show they are additive). Emissions reductions per head were applied based on literature values of 3.0% to 8.0% for Monensin, with the conservative value of 3.0% being used, and 38.5% for 3-NOP. The total emissions reductions were calculated as the difference in enteric methane emissions between the BAU and the mitigation scenario, expressed in $MTCO_2e$.

Key assumptions include:

- Adoption rates would be applicable to 100% of dairy, feedlot and beef cattle, excluding calves. This broad applicability reflects the potential for sector-wide implementation once adoption barriers are addressed.
- Effects of Monensin and 3-NOP are not additive due to lack of consensus of research on combined feed additives and associated effects, therefore when 3-NOP adoption ramps up, assume zero effect from Monensin.
- Monensin assumed to be market-ready with low implementation costs. Adoption ramps from 3% in 2026 to 30% by 2035.
- 3-NOP is Food and Drug (FDA)-approved but faces consumer and cost-related barriers. Adoption begins in 2035.
- Adoption curves reflect realistic market penetration based on current regulatory status, economic feasibility, and producer behavior.

Limitations include:

- Applicability assumptions: The analysis assumes that 100% of beef forage cattle, beef feedlot cattle (excluding calves), and dairy cattle are eligible for feed additive treatment. In practice, variability in farm management practices, regional feed availability, and animal health considerations may limit full adoption. This simplification was used to estimate the maximum technical potential of the measure and can be refined with more granular, region-specific adoption data.
- Data or Modeling Limitations - Non-Additive Emissions Reductions: Assumes Monensin and 3- NOP effects on enteric fermentation emissions are not additive. The model conservatively assumes that the methane-reducing effects of Monensin and 3-NOP are not additive, despite emerging evidence suggesting potential synergy. This simplification avoids overestimating emissions reduction potential in the absence of definitive scientific consensus.
- Sensitivity to External Factors- Adoption: Monensin is market ready and there is a low cost to implementation; methods assume adoption from 2026-2035. 3-NOP is FDA approved however consumer hesitation and cost barriers remain which deter producers from implementation; methods assume adoption from 2036-2050. Adoption of Monensin (2026–2035) and 3-NOP (2036–2050) is modeled using linear ramp-up scenarios of 3-30% and 5-100%, respectively. These projections do not account for potential disruptions such as supply chain issues, regulatory changes, or shifts in consumer demand. While these assumptions provide a structured framework for long-term planning, future iterations could incorporate dynamic adoption models based on economic or behavioral drivers. Assumed impact on GHG emissions is based on literature (% reduction per animal head with feed additive). GHG reduction percentages per animal are based on literature averages, which may not reflect performance under diverse real-world conditions (e.g., diet composition, animal genetics, climate). These values were selected to align with established methodologies (e.g., USDA MACC) and provide a consistent basis for comparison across emissions reduction strategies.

Data sources include:

- USDA NASS Quick Stats
- Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 | US EPA, Table A-148

- EPA SIT Agriculture Module
- USDA Marginal Abatement Cost Curve Estimate Methodology Report
- Arndt, et al, 2022. "Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 °C target by 2030 but not 2050"
- Hegarty, et al, 2021. "An evaluation of emerging feed additives to reduce methane emissions from livestock"

Cost Approach

Cover Crops

Consistent with the USDA MACC Report (2023), no capital costs for cover crop adoption were assumed for the state of Virginia. Operating & maintenance (O&M) costs include seed costs (species-dependent), labor and fuel for management, planting and termination. These were modeled as annual per-acre costs and scaled with adoption rates. 2025 Virginia Environmental Quality Incentives Program (EQIP) payments for "Cover Crop – Basic" practice (34-EQIP) were assumed to serve as a proxy for 75% of the total costs to farmers for adopting cover crops and scaled this value to 100% of costs in estimates.

Uniform adoption costs across crop types (i.e., no cost differentiation between field crops and vegetables) were assumed. It is important to note that EQIP payment rates do not account for co-benefits from cover crop adoption that may result in cost savings. To incorporate these benefits, the average inflation-adjusted values from the first year of cover cropping, as reported in Table 10 of the USDA MACC Report (2023), were subtracted from EQIP payments.

Cost distribution was modeled as recurring annual per-acre costs, increasing over time in line with adoption rates. Costs were scaled by projected eligible cropland acreage (i.e., the sum of field crops and vegetables).

Nitrification Inhibitors

For nitrification inhibitors (NI), capital costs included any per-acre costs associated with incorporating NI products into fertilizer applications. These were treated as annualized costs rather than upfront capital investments. Consistent with the USDA MACC Report (2023), no additional capital costs are associated with NI adoption. O&M costs were minimal as NIs are integrated into existing fertilizer application practices. Any additional labor or equipment calibration costs were included in the per-acre cost estimates. Labor costs were based on the USDA MACC Report (Table 4, Appalachia region). Virgina E payments for "nutrient Management" practice (590A-EQIP) were assumed to serve as a proxy for 75% of the total cost to farmers for adopting NIs. A10% reduction in fertilizer application results in a proportional 10% reduction in fertilizer costs were assumed, consistent with the USDA MACC Report.

Cost distribution was modeled as recurring annual per-acre costs, increasing over time in line with adoption rates. Costs were scaled by crop-specific adoption trajectories and fertilized acreage.

Feed Management

Consistent with the USDA MACC Report (2023), no capital costs are associated with feed additive adoption, as feed additives are incorporated into existing feeding systems. O&M costs may include additive costs per head per year (varying by product and dosage), as well as labor and management for additive integration. These were modeled as annual per-head costs, scaled with adoption rates and livestock populations. Cost distribution increased over time in line with the phased adoption of Monensin and 3-NOP. Monensin feed additive costs were based on the USDA MACC Report. "Monensin, Beef" costs were assumed to apply to both beef cattle and dairy cows. 3-NOP feed additive costs were based on Luke and Tonsor (2024) and similarly assumed to apply to beef cattle and dairy cows. A 6.4% increase in feed efficiency from Monensin and 3-NOP use, respectively, was assumed to result in a corresponding decrease in fertilizer costs.

Cost distribution was modeled as recurring annual costs per animal, increasing over time in line with adoption rates. Costs were scaled by livestock population trajectories.

Table B5: Measure NWL 3 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Cover Crop Adoption	-	0.36	0.72	1.08	1.36	1.36	21.80
Nitrification Inhibitors	-	0.52	1.14	1.86	2.72	3.11	43.14
Feed Management	-	0.01	0.02	0.21	0.46	0.49	4.93
Total Costs	**-**	**0.88**	**1.86**	**2.95**	**4.07**	**4.47**	**64.94**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $64.94

Cost data sources include:

- USDA Marginal Abatement Cost Curve Estimate Methodology Report
- Virginia Environmental Quality Incentives Program
- Luke, J. R., & Tonsor, G. T. (2024). "The enteric methane emission conundrum: U.S. beef cattle producer adoption of climate-focused technology". *Sustainable Production and Consumption*, 364-375.
- Federal Reserve Bank of St. Louis Table Data – Gross Domestic Product: Implicit Price Deflator.

Transportation

For the transportation sector measures, GHG reductions were quantified for both on-road and aviation sources. Modeled activities include increasing the adoption of ZEVs, replacing conventional diesel fuel from on-road vehicles with renewable diesel, reducing vehicle miles traveled (VMT) through actions that promote mode shift and land use efficiency, and transitioning to sustainable aviation fuel (SAF). SAF was incorporated as an additional modeling component to support progress toward the MSA's net zero emissions targets. Table B6 shows the cumulative emission reductions modeled from each measure. Collectively, these measures are projected to decrease emissions by 29.58 $MMTCO_2e$ from 2025 through 2050.

Table B6: Summary of Transportation Sector CCAP Measure GHG Reductions ($MMTCO_2e$)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Increase the adoption of LEVs and ZEVs by developing education, outreach, and planning materials to localities for purchasing and maintaining ZEVs and develop a fueling infrastructure deployment strategy	0.84	24.49
Reduce VMT and support alternative modes of transportation through bike/pedestrian infrastructure investments	0.29	2.88
Sustainable aviation fuel*	-	2.21

* Additional modeling components to reach net zero targets

T1: Increase the adoption of low and zero-emission vehicles by developing education, outreach, and planning materials to localities for purchasing and maintaining ZEVs and develop a fueling infrastructure deployment strategy

GHG Methodology

Zero-Emission Vehicles

The modeling estimated potential GHG emission reductions from increasing the use of ZEVs, such as battery electric vehicles (BEVs).

Key assumptions include:

- ZEVs exist in the vehicle fleet for the same length of time as internal combustion engine vehicles (ICEVs).
- ZEV activity/use is identical to an ICEV.
- Annual ZEV sales fraction applies to every fuel type.
- ZEV sales curves:
  - 100% of new light duty (LD) vehicle sales are battery electric vehicle (BEV) by 2035, in alignment with the most advanced policy in place at the time of modeling - California's Advanced Clean Cars II rule.
  - 100% of new medium and heavy duty (MHD) vehicle sales are BEV by 2050. This aligns with the Multi-state Medium -and Heavy Duty Zero Emission Vehicle Memorandum of Understanding, which Virginia signed in 2021.
  - Curves ramp linearly from historical BEV sale rates.

Limitations include:

- Successful ZEV adoption requires EV charger installation and accessibility. The pace of charging infrastructure deployment, EV model availability at similar costs to ICEVs, and electricity rates will all impact the adoption rate of EVs.

Data sources include:

- EPA Motor Vehicle Emissions Simulator version 5 (MOVES5)

Renewable Diesel

Even with aggressive electrification, there will still be conventional vehicles on the roads in 2050. Alternative diesel fuels are one option to reduce emissions from remaining internal combustion engine vehicles (ICEVs). Renewable diesel is a "drop-in" fuel, meaning it can be blended with or used in place of conventional diesel without modifications to the vehicle. Because renewable and conventional diesel have similar combustion emissions, a life-cycle emissions factor was used to capture emissions reductions that occur earlier in the production chain.

Key assumptions include:

- 100% of the diesel supply is composed of renewable diesel by 2050
- Renewable diesel adoption begins in 2031 and grows linearly through 2050.
- The carbon intensity of renewable diesel is 65% lower than conventional diesel, per NREL's Alternative Fuels Data Center under a lifecycle emissions approach.
- There is enough renewable diesel available in the region to supply the demand.

Limitations include:

- The actual carbon intensity of renewable diesel could be different depending on the feedstocks used in production.

Data sources include:

- Alternative Fuels Data Center: Renewable Diesel

Cost Approach

Zero-Emission Vehicles

Costs include both the upfront capital investments required to purchase new vehicles and install new EV supply equipment (EVSE), as well as the recurring fuel and vehicle maintenance costs. Due to the phaseout of federal tax incentives for EVs, no financial incentives were assumed. Cost estimates represent the net change in total costs between the zero-emission adoption scenario and the BAU scenario.

Vehicle capital costs associated with electrification were estimated by multiplying the projected number of new vehicle purchases in each model year by the average purchase price per vehicle. These costs were differentiated by vehicle class (e.g., passenger car, single-unit short-haul truck, transit bus) and engine type (e.g., internal combustion engine, battery EV). The average cost per vehicle reflects the additional upfront cost of EVs compared to conventional vehicles, accounting for technology improvements and cost declines over time. EVSE capital costs were estimated assuming one level 2 charger per LD EV, one 50 kW fast charger per Class 2b - 6 MHD EV, and one 150 kW fast charger per Class 7 – 8 MHD EV. All capital costs were assumed to occur at the time of vehicle replacement, consistent with adoption curves and equipment lifetime assumptions.

Energy costs and savings associated with electrification and energy efficiency were estimated using projected annual energy use for each fuel type (e.g., gasoline, diesel) by the corresponding projected cost per unit of fuel, derived from EIA's Annual Energy Outlook 2025. Electricity prices were calculated using electricity prices from residential sector for LD EVs and electricity prices from commercial sector for MHD EVs.

Vehicle maintenance costs were estimated by multiplying the VMT for each vehicle and engine type by an average maintenance cost per mile ($/mi). These per-mile costs were specific to each powertrain type and reflect differences in maintenance needs between electric and conventional vehicles, such as reduced brake wear and fewer moving parts in electric drivetrains. These per-mile costs were derived from Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool.

Table B7: Measure T1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	134.21	765.72	1,320.94	1,502.69	1,645.59	1,768.36	31,926.05
Operational Costs	22.18	(122.17)	(214.22)	(397.44)	(546.65)	(775.12)	(8,599.42)
Total Costs	**156.39**	**643.55**	**1,106.72**	**1,105.25**	**1,098.94**	**993.24**	**23,326.62**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $23,326.6

Cost data sources include:

- Vehicle capital costs: Projections of vehicle capital cost by type and fuel using AFLEET
- Projected fuel and electricity prices: EIA's Annual Energy Outlook 2025, Table 3
- Vehicle maintenance cost: AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)

Renewable Diesel

The incremental cost of renewable diesel was evaluated by calculating the difference in unit price between renewable diesel and conventional diesel, then multiplying that difference by the projected volume of renewable diesel consumed. This approach quantifies the cost premium associated with using renewable diesel in place of conventional fuel.

To reflect the higher cost of renewable diesel prior to the implementation of regulatory incentives or market-based programs, a cost of $4.80 per gallon for renewable diesel was assumed. This represents the estimated cost of alternative fuels in the absence of subsidies and credits to capture the full economic burden of alternative fuel adoption in a pre-regulatory context.

Table B8: Measure T1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Total Costs	**-**	**-**	**26.37**	**38.00**	**36.29**	**25.94**	**595.87**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $595.87

Cost data sources include:

- EIA's Annual Energy Outlook 2025, Table 3 to forecast conventional diesel price
- ICF's estimation of renewable diesel cost is based on existing pricing reports, e.g. Clean Cities and Communities Alternative Fuel Price Report, January 2025

T2: Reduce vehicle miles traveled and support alternative modes of transportation through bike/pedestrian infrastructure investments

GHG Methodology

The modeling estimated potential GHG Reductions from various strategies to reduce VMT, including land use changes, improved transit travel times, increased walk and bike access, and uptake of micromobility solutions.

The Trip Reduction Impacts of Mobility Management Strategies (TRIMMS) tool was used to estimate the impact of changes in trip price and length on mode share. Reductions in transit cost and transit and active transportation trip time shift transportation mode share away from personal vehicles to public transit and active transportation. TRIMMS outputs were leveraged to estimate VMT change.

A VMT reduction schedule was developed that resulted in a 11.64% VMT reduction by 2050 based on the TRIMMS modeling. Reductions were assumed to begin in 2026 and were linearly interpolated to 2050. The VMT reduction was applied to light duty vehicles only and emission reductions were added after Measure T1. This is important to avoid double-counting reductions; VMT reductions from EVs do not lead to emission reductions but do have other quality of life and place co-benefits.

Key assumptions include:

- Free public transportation
- 10% decrease in public transportation trip time
- 10% decrease in pedestrian trip time
- 10% decrease in bike trip time
- VMT reductions applied to the region assuming the ZEV transition in T1 occurs

Limitations include:

- TRIMMS uses regional-average trip characteristics to estimate mode and VMT change and thus does not capture regional variation.
- TRIMMS also relies on the resulting change from policy decisions, rather than the policy itself. For example, TRIMMS leverages changes in trip or access time instead of using miles of expanded transit routes or number of new stops. Therefore, all TRIMMS inputs are assumptions.

Data sources include:

- 2020 Census and 2020 American Community Survey for regional inputs
- Replica to model both VMT share and current trip costs and time

Cost Approach

A custom cost calculator was developed to estimate the cost per mile of VMT reduced, expressed as $/mi VMT reduced. This metric was derived from a representative sample of transit and active transportation investment projects implemented across the United States. The calculator aggregates capital and operating costs associated with these projects and relates them to the amount of VMT reduction achieved, providing a standardized cost-effectiveness measure.

Based on the analysis of representative projects, the estimated capital cost of transit and active transportation investments is $0.14 per VMT reduced for the project lifetime. This includes infrastructure development such as bike lanes, pedestrian pathways, and e-bike programs.

Operational expenses include the following three types of costs:

- The operations and maintenance costs of transit investments were estimated at $1.00 per VMT reduced. This includes ongoing expenses such as transit incentives (free fare), improved transit service operation, and equipment maintenance necessary to sustain the VMT reductions over time.
- Energy savings associated with reduced VMT electrification were estimated using projected annual energy use for each fuel type (e.g., gasoline, diesel) by the corresponding projected cost per unit of fuel, derived from EIA's Annual Energy Outlook 2025. Electricity prices were calculated using electricity prices from the residential sector for LDV.
- Vehicle maintenance savings were estimated by multiplying the VMT for each vehicle and engine type by an average maintenance cost per mile. These per-mile costs were derived from Argonne National Laboratory's AFLEET tool and were specific to each vehicle powertrain type.

Table B9: Measure T2 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	47.98	98.61	152.57	211.24	277.32	3,376.49
Operational Costs	-	243.59	536.72	877.02	1,256.46	1,678.34	19,540.19
Total Costs	**-**	**291.57**	**635.33**	**1,029.59**	**1,467.70**	**1,955.66**	**22,916.68**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $22,916.68

Cost Data Sources:

- EIA's Annual Energy Outlook 2025, Table 3 to project fuel and electricity costs
- AFLEET to model vehicle maintenance costs

Sustainable Aviation Fuel

The best option to decarbonize aviation available today is to replace petroleum-based jet fuel with biomass- or waste-based fuel, commonly referred to as sustainable aviation fuel. SAF is a chemical equivalent to conventional jet fuel but releases a fraction of the emissions from a lifecycle perspective because the carbon released was recently sequestered by its feedstock – typically a crop, waste oil or other biomass. This is similar from an emissions accounting perspective to renewable diesel used in Measure T1. The barrier to SAF uptake is production cost, which are at least two times the cost of conventional jet fuel. A number of incentives like the Federal Renewable Fuel Standard and California's Low Carbon Fuel Standard offset the cost of SAF but are likely insufficient to induce demand at scale.

To further offset the costs, some states like Illinois and Washington have implemented a SAF tax credit. The purpose of a SAF tax credit is to provide direct cash to the producer or off-taker (the airline) to reduce or eliminate the price premium for SAF. To model SAF uptake, additional tax credits were assumed to be made available over time at a level sufficient to lead to higher levels of SAF blending.

GHG Methodology

Potential GHG reductions from an additional SAF incentive were estimated by comparing BAU jet fuel emissions to emissions under a scenario with increased SAF adoption. Emissions were evaluated on a lifecycle basis, meaning the carbon intensity of a gallon of fuel includes emissions associated with crude extraction, feedstock cultivation, transportation, refining, distribution, and combustion. Because SAF and conventional jet fuel have similar combustion emissions, a life-cycle analysis is important for capturing emissions reductions that occur earlier in the production chain.

To estimate SAF adoption at different incentive levels, renewable diesel (RD) market dynamics were used as a proxy[1]. A time-series analysis aligned historical incentives, diesel market prices, and RD production costs to predict production volumes based on profitability trends. The strongest relationship occurred at a 13-quarter lag, suggesting that profitability typically takes approximately three years to translate into new production capacity.

Profitability was forecasted using ICF projections for key components of SAF production costs and revenue streams. A third-party provider supplied feedstock price forecasts, which represent a major share of production costs. These data were combined with internal analysis of cost of capital and other operating expenses. Revenue assumptions were also informed by crude oil price projections and the Renewable Fuel Standard, both of which constitute large portions of producer revenue.

Key assumptions include:

- SAF tax incentive that results in close to 100% SAF blend by 2050. A constant $0.40/gallon SAF tax credit is assumed.
- Blend restrictions are resolved: Currently the American Society for Testing and Materials has approved pathways for SAF production that only allow a 50% blend of SAF with conventional jet fuel. The modeling contemplates a future where SAF is close to 100% of the jet fuel pool. While technically feasible, it would require a SAF producer to undergo the necessary steps to acquire qualification for higher blends.

[1] RD is a suitable proxy for SAF because both rely on HEFA pathways, share feedstocks, and operate under similar incentive structures. Their recent emergence, high blend potential (e.g., RD reaching 70% in California), and status as drop-in fuels requiring no infrastructure or engine modifications make RD's trajectory a valuable indicator for SAF market development.

- Feedstocks are available: The current SAF industry is dominated by HEFA (Hydroprocessed Esters and Fatty Acids) production pathways that use soybean oil, used cooking oil or other crops or waste oils as a feedstock.[2] These feedstocks are in high demand currently because of the expansion in the RD and SAF industries. As demand for HEFA feedstocks approaches supply constraints, it is anticipated that other pathways like alcohol to jet (ATJ), which uses ethanol to produce jet fuel, would be utilized. Feedstocks of ethanol and corn (to produce the ethanol) have spare but finite capacity. Electrification of the on-road transportation sector may free up feedstocks as demand for RD and ethanol falls. Rather than model these various dynamics in the feedstock markets, the modeling assumes that feedstocks will not be a constraint to industry expansion nor that they will significantly rise in price in real dollar terms.
- SAF Industry Development will mirror RD Development given the same profitability profile. Because the SAF industry has low production to date, it is difficult to use past data for SAF to develop a view of the future. Therefore, it became necessary to find a corollary to SAF that had a stronger data history to analyze. RD has many characteristics that make it a helpful corollary which are articulated above. For these reasons, the modeling relied on RD production history to develop a theory around what will be required for SAF industry expansion.

Limitations include:

- The aviation sector does not reach net zero emissions despite using 100% SAF. For the aviation industry to claim carbon neutrality, it will be necessary to implement other measures like carbon capture and sequestration or carbon offset credits from other economic sectors.
- RD as a proxy market for SAF:
  - In the relevant incentives like the California Low Carbon Fuel Standard (LCFS), diesel is an obligated fuel, meaning that if a refiner blends RD, they both avoid generating a deficit by producing less diesel and generate a credit. Jet fuel is not obligated, so blending SAF only provides a credit and does not avoid any deficits. This feature essentially doubles the value of RD in comparison to SAF in these incentives and makes rapid expansion of RD valuable to regulated parties. This difference was accounted for by awarding LCFS value to RD for both the avoided deficits and the credits, which expands the calculated profitability when the relationship between profitability and production is analyzed. When this is applied to SAF production outlooks, the model essentially demands that incentive value rises to the same levels as if SAF was being credited for both avoided deficits and credits.
  - Over the course of RD's rapid expansion, the fuel was certified to be blended to 100% levels, meaning there was no regulatory limit to diesel purchased at the pump from being entirely renewable. The safety considerations inherent in the aviation sector make the process for such certification much more complex. Today almost all SAF pathways are certified for 50% blends. Given the low percentage of SAF in the market today, this is not a barrier to expansion in the industry, but at the levels contemplated in this study, certification will have to be granted for 100% blends by around the mid-2030s.
- Initial volumes of SAF production were assumed to be produced using HEFA pathways. That technology pathway is one of a number of possible ways to produce SAF including ATJ and Fischer Tropsch (FT). Currently, HEFA is the only pathway that actually produces SAF at commercial scale, although there have been significant developments for other pathways. FT pathways do not reach commercial viability during the forecast period and that ATJ pathways develop in a similar pattern to HEFA was assumed. Technological development of FT pathways faster than anticipated could result in outcomes different from the current analysis.

Data sources include:

- CARB
- U.S. EIA

[2] The HEFA production process for SAF involves hydroprocessing vegetable oils, animal fats, or used cooking oil. The feedstocks are first deoxygenated and then the resulting hydrocarbons are hydrocracked and isomerized to meet jet fuel specifications, after which the SAF is blended with conventional jet fuel.

- OPIS
- Fastmarkets

Cost Approach

The incremental cost of SAF implementation was estimated by multiplying the projected SAF consumption by the cost difference between SAF and conventional jet fuel. To reflect the cost of SAF prior to the influence of federal incentives and market scaling, the modeling used a production cost of $7.00 per gallon. This metric represents the estimated cost of producing SAF using current technologies and feedstocks, such as HEFA or alcohol-to-jet pathways. SAF production costs are significantly higher than conventional jet fuel due to limited commercial-scale production, feedstock availability, and complex refining processes. For conventional jet fuel, the modeling relied on price forecasts from the EIA's Annual Energy Outlook 2025.

To account for policy-driven cost reductions, the analysis accounted for the SAF tax credits established to facilitate SAF adoption. The tax credit is designed to incentivize SAF production and adoption by offsetting part of the cost differential with conventional fuels.

Table B10: Measure SAF Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Total Costs	**-**	**-**	**-**	**127.70**	**124.61**	**121.70**	**1,773.48**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $1,773.48

Cost data sources include:

- EIA's Annual Energy Outlook 2025, Table 3

Buildings

For the building sector measures, GHG reductions were quantified for new and existing residential, commercial, and industrial buildings. Modeled activities include improvements in energy efficiency, increased adoption of electric appliances and equipment, the development of high-performance buildings, and the use of renewable natural gas (RNG). Collectively, these measures are projected to avoid approximately 44.22 $MMTCO_2e$ from 2025 through 2050.

Table B11: Summary of Buildings Sector CCAP Measure GHG Reductions ($MMTCO_2e$)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for municipal and school buildings.	0.08	0.80
Reduce energy consumption and increase building decarbonization through programs to support, incentivize, and install energy efficiency and electrification measures in residential buildings.	1.51	17.15
Increase energy efficiency in existing commercial and industrial buildings through financial incentives and educational outreach programs.	1.32	26.28

B1: Provide technical and financial assistance for energy efficiency, electrification, and other investments to achieve net zero operations for municipal and school buildings.

GHG Methodology

GHG emission reductions from municipal and school buildings were estimated using the commercial sector energy savings modeled in measure B3. This analysis draws heavily from NREL's State and Local Planning for Energy (SLOPE) Scenario Planner to estimate potential energy savings from efficiency improvements implemented throughout the region's building stock. A detailed description of this methodology is provided in Measure B3.

Total commercial energy savings from SLOPE's Best Available Energy Efficiency (BAEE) scenario were allocated to the municipal building stock by applying the share of commercial energy use attributable to municipal buildings. This share was derived from the City of Richmond's Citywide and Municipal GHG Inventories, which was used as a proxy for the Hampton Roads MSA as a regionally applicable publicly available commercial and municipal sector inventory.

Key assumptions include:

- Municipal and school buildings were assumed to have similar baseline energy intensity and end-use patterns as the broader commercial building stock.
- Municipal and school building energy consumption as a share of total commercial energy consumption was assumed to follow similar patterns observed in the City of Richmond's GHG Inventories.
- Commercial energy savings from the SLOPE BAEE scenario was assumed to reasonably approximate the scale of achievable energy efficiency improvements in municipal and school buildings within the Hampton Roads MSA.
- Natural gas, fuel oil, and propane use were assumed to decrease proportionally to changes in non-electric fuel use under the BAEE scenario.
- Efficiency improvements were assumed to occur primarily through end-of-life equipment replacements rather than through accelerated retrofits.

Limitations include:

- SLOPE outputs are modeled at the state level and may not capture local variations in building type, age, occupancy, or energy intensity across municipal and school facilities in the Hampton Roads MSA.
- Municipal and school buildings represent a small and distinct subset of the commercial sector; their energy use profiles and retrofit potential may differ from private commercial buildings.
- The SLOPE BAEE scenario emphasizes energy efficiency improvements and does not model full building electrification. As a result, estimated emission reductions may understate the potential GHG benefits achievable under a more aggressive electrification pathway supported by continued grid decarbonization.
- The analysis does not account for factors such as limited staff capacity, funding constraints, or procurement challenges that could delay or reduce project implementation in the public sector.

Data sources include:

- NREL Slope Scenario Planner to estimate state-level change in energy consumption under the Best-Available Energy Efficiency in Buildings scenario.
- US Census to estimate each county's share of its state population in 2022, used to scale statewide results to the Hampton Roads MSA.
- City of Richmond's Citywide and Municipal GHG Inventories to estimate the share of total commercial energy consumed by municipal buildings.

Cost Approach

Demand-side system costs from NREL's SLOPE tool were used to quantify the costs of implementing energy efficiency upgrades in municipal and school buildings. These include both the upfront investments required to install efficient equipment (capital costs) and the long-term impacts on customer utility bills resulting from changes in electricity and fuel consumption (operational costs).

Table B12 presents the annual and cumulative capital and operational costs associated with implementing this measure. Relative to the BAU scenario, accelerating the adoption of energy efficiency and electrification retrofits increases near-term capital expenditures. In contrast, operational costs show net savings over time, driven by reduced energy consumption from efficiency improvements that accumulate throughout the study period. In aggregate, cumulative total costs are negative across the projection horizon, reflecting long-term bill savings that exceed incremental capital investments.

Consistent with the GHG modeling approach, state-level system costs from SLOPE's BAEE scenario were scaled down using each county's share of its state population. Additional details on the cost allocation approach for commercial buildings are discussed under Measure B3.

Table B12: Measure B1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	1.27	1.10	0.34	0.41	0.20	20.55
Operational Costs	-	(2.68)	(4.16)	(5.31)	(5.53)	(5.24)	(106.85)
Total Costs	**-**	**(1.42)**	**(3.06)**	**(4.97)**	**(5.12)**	**(5.03)**	**(86.30)**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $(86.30)

Cost data sources include:

- NREL Slope Scenario Planner to estimate state-level system costs under the Best-Available Energy Efficiency in Buildings scenario.
- US Census to scale statewide results to the Hampton Roads MSA.
- Dominion Energy's Evaluation, Measurement, and Verification Report to estimate costs per MWh saved from Dominion's residential and non-residential energy efficiency programs, used to allocate the share capital costs attributable to commercial buildings.
- City of Richmond's Citywide and Municipal GHG Inventories to estimate the portion of commercial costs attributable to municipal buildings. Richmond's publicly available dataset was used as a proxy for localities in the region to determine the share of the commercial sector that could be attributed to municipal buildings.

B2: Reduce energy consumption and increase building decarbonization through programs to support, incentivize, and install energy efficiency and electrification measures in residential buildings.

GHG Methodology

Existing Residential Buildings

Potential GHG emission reductions from implementing energy efficiency and electrification retrofits in residential buildings were quantified using NREL's SLOPE Scenario Planner. The analysis scaled down state-level energy consumption outputs from SLOPE's BAEE scenario, which uses NREL's Scout Core Measures Scenario Analysis to model adoption of both commercially available and emerging high-efficiency equipment and building envelope technologies across U.S. residential and commercial buildings.

The Scout model quantifies site-level energy savings by comparing efficient technologies to baseline equipment across major end uses, including space heating, cooling, water heating, and lighting. It assumes that building energy efficiency increases over time as consumers adopt aggressive energy conservation measures that reduce direct fuel use in buildings. Relative to the reference scenario, these measures yield a nationwide reduction in energy consumption of approximately 22% by 2050 for residential and commercial buildings. Additionally, end-use electrification is projected to increase over time due to a combination of technology cost and performance improvements as well as incentives under the IRA.

National-level results from Scout were first disaggregated to the state level based on state level projections of energy efficiency potential from Electric Power Research Institute (EPRI). Statewide results for Virginia and North Carolina were then scaled to the Hampton Roads MSA using county population shares. Reductions in residential electricity and fuel use were calculated relative to the reference case and scaled to the BAU scenario.

Key assumptions include:

- The SLOPE BAEE scenario was assumed to reasonably approximate the scale of achievable energy efficiency improvements in the Hampton Roads MSA by 2050. This model assumes that energy efficiency of residential and commercial buildings increases over time, consistent with consumers pursuing aggressive energy conservation measures, including equipment, envelope, and other efficiency improvements that reduce direct fuel use in buildings. End-use electrification is also assumed to grow over time due to a combination of technology cost and performance improvements as well as incentives from the IRA.
- Modeled state-level energy efficiency potentials for Virginia and North Carolina were assumed to be representative of trends within the Hampton Roads MSA.
- Natural gas, fuel oil, and propane use were assumed to decrease proportionally to changes in non-electric fuel use under the BAEE scenario.

Limitations include:

- SLOPE outputs are modeled at the state level and may not capture local variations in housing stock characteristics, climate conditions, income levels, or program participation rates across the Hampton Roads MSA.
- The analysis does not account for implementation barriers such as limited consumer awareness, upfront cost constraints, or workforce availability, which may affect the scale and timing of adoption.

Data sources include:

- NREL Slope Scenario Planner to estimate state-level change in energy consumption under the Best-Available Energy Efficiency in Buildings scenario.
- US Census to estimate each county's share of its state population in 2022, used to scale statewide results to the Hampton Roads MSA.

New Residential Buildings

Potential GHG emission reductions from developing energy-efficient and primarily electric new residential buildings were quantified based on projected improvements in state building energy codes and expanded building electrification. Modeling assumed that Virginia and North Carolina adopt updates to the International Energy Conservation Code (IECC) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 standards at regular intervals from 2026 through 2050, with compliance assumed for all new buildings based on a 30-year measure life. New residential building growth projections were based on available forecasts for the region. A fossil fuel combustion phase-out is also assumed in later projection years, in addition to a certain percentage of buildings assumed to be built to a green buildings code.

Key assumptions include:

- Energy code compliance was assumed for all new buildings based on a 30-year measure lifetime.
- Updated IECC and ASHRAE 90.1 standards are adopted every six years.
- New residential home growth was based on household growth rates from the Weldon Cooper Center for Public Service (VA) and the North Carolina Office of State Budget and Management (NC).
- Multifamily residential buildings represent 27% of newly constructed homes in 2026, growing linearly to 65% by 2050.
- Multifamily building energy usage was modeled as 50% of single-family usage, consistent with EPA studies.
- The green buildings standard corresponds to Passive House specifications, representing all-electric homes meeting a 13.6 kBtu/ft^2 site energy use intensity (EUI), decreasing in line with energy code progression. Adoption increases linearly from 1% in 2026 to 15% by 2050.
- Heat pump efficiency growth follows the residential moderate advancement scenario from NREL's 2018 Electrification Futures Study.
- Electrification rates continue historical trends until the fossil fuel phase-out for new construction begins in 2035.

Limitations include:

- New residential building projections depend heavily on household growth rates. Changes to these rates will directly influence total emissions reductions.
- New buildings modeling is simplified by only accounting for the fuel usage and EUI per residential home. In actuality, there are numerous types of housing (detached vs. attached single family homes, multifamily buildings with a variety of units, etc.) that the modeling cannot reasonably account for. As such, deviations in energy usage based on the growth rates of different types of buildings are to be expected. EUI is also a simplified annual metric that does not take into account specific building equipment types. The modeling assumed that increases in equipment efficiencies are expected to continue, but future energy consumption may be higher if this assumption changes (such as due to state/federal policies, economic/technological limitations, or other barriers).
- The projected split between single-family and multi-family housing in the region will also affect the energy consumption of new buildings. Further state policies as well as demographic/land usage shifts have the potential to alter these projected trends.

Data sources include:

- Household growth projections from the Weldon Cooper Center for Public Service (VA) and the North Carolina Office of State Budget and Management (NC).
- Energy usage data from Pacific Northwest National Laboratory (PNNL) cost-effectiveness studies for VA and NC IECC/ASHRAE codes, Passive House standards, and ENERGY STAR estimates.
- Heat pump efficiency growth from NREL's 2018 Electrification Futures Study.

Data sources include:

- Growth projections for households from the Weldon Cooper Center for Public Service and the North Carolina Office of State Budget and Management.
- Energy usage based on data from PNNL cost-effectiveness studies for VA IECC and ASHRAE codes along with NC IECC and ASHRAE codes, Passive House standards, and ENERGY STAR estimates.
- Heat pump efficiency growth from NREL's 2018 Electrification Futures study.

Cost Approach

Existing Residential Buildings

Demand-side system costs from NREL's SLOPE tool were used to quantify the costs of implementing energy efficiency upgrades in existing residential buildings. These include both the upfront investments required to install efficient equipment (capital costs) and the long-term impacts on customer utility bills resulting from changes in electricity and fuel consumption (operational costs). Relative to the BAU scenario, accelerating the adoption of efficiency and electrification retrofits increases near-term capital expenditures. In contrast, operational costs show net savings over time, driven by reduced energy consumption from efficiency improvements that accumulate throughout the study period. As shown in Table B13, cumulative total costs are negative across the projection horizon, reflecting long-term bill savings that exceed incremental capital investments.

Consistent with the GHG modeling approach, state-level system costs from SLOPE's BAEE scenario were scaled down using each county's share of its state population. For the residential sector, capital costs were allocated based on relative costs per MWh saved from residential energy efficiency programs reported in Dominion Energy's Evaluation, Measurement, and Verification Report. Fuel consumption costs were allocated according to the residential sector's share of total annual fuel and electricity savings.

Table B13 presents costs for existing and new residential buildings. Operational costs also include RNG-related costs, estimated by multiplying annual RNG consumption by the median price reported in the American Gas Foundation's Renewable Natural Gas Supply Assessment. These estimates reflect only the commodity purchase cost of RNG.

Table B13: Measure B2 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	33.92	50.73	34.77	52.90	47.86	1,084.81
Existing Residential Buildings	-	29.72	36.81	14.51	25.84	21.44	689.63
New Residential Buildings	-	4.21	13.92	20.26	27.06	26.41	395.18
Operational Costs	2.23	(73.61)	(97.89)	(112.39)	(141.23)	(150.28)	(2,556.73)
Existing Residential Buildings	2.23	(72.35)	(93.27)	(103.39)	(126.02)	(128.28)	(2,343.37)

	2025	2030	2035	2040	2045	2050	2025-2050
New Residential Buildings	-	(1.26)	(4.63)	(8.99)	(15.21)	(22.00)	(213.36)
Total Costs	**2.23**	**(39.69)**	**(47.16)**	**(77.61)**	**(88.33)**	**(102.43)**	**(1,471.91)**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $(1,471.91)

Cost data sources include:

- NREL Slope Scenario Planner to estimate state-level system costs under the Best-Available Energy Efficiency in Buildings scenario.
- US Census to scale statewide results to the Hampton Roads MSA.
- Dominion Energy's Evaluation, Measurement, and Verification Report to estimate costs per MWh saved from Dominion's residential and non-residential energy efficiency programs, used to allocate the share capital costs attributable to residential building retrofits.
- American Gas Foundation's Renewable Natural Gas Supply Assessment (2025) to estimate RNG prices.

New Residential Buildings

For new buildings, costs were estimated for both upfront costs and operational costs (reflecting energy usage change). Cost results for new residential buildings are shown in Table B13.

Upfront costs were split between code improvements and additional stretch/green buildings code costs. The upfront cost calculations for implementing energy efficiency through code improvements were extrapolated based on the costs and savings estimated in the most recently available PNNL cost-effectiveness studies. For residential buildings, this was IECC 2021 in VA and IECC 2018 in NC; for commercial buildings, ASHRAE 90.1 2019 was used. These costs estimates were multiplied by the number of residential homes (single and multifamily) or commercial square footage in each city/county to reach the totals.

To reflect the additional costs of a stretch/green buildings code, new residential buildings meeting this additional standard were modeled to achieve Passive House EUI requirements. Costs for Passive House implementation were sourced from Passive House Institute U.S. ("Phius") cost data research, with state new construction cost estimates sourced from Home-Cost. New commercial buildings were modeled to meet EUI standards corresponding to a Portfolio Manager ENERGY STAR score of 90 for the low scenario and the 2019 ASHRAE Advanced Energy Design Guide for Small to Medium Office Buildings - Zero Energy report for the high scenario, with cost estimates derived from studies by Built Environment Plus and BR+A, along with construction cost estimates from RSMeans.

Energy cost savings from new buildings were calculated based on changes in fuel and electricity consumption relative to baseline code-compliant construction. Fuel prices were sourced from EIA and escalated using growth rates from EIA's Annual Energy Outlook 2025 (Table 3). RNG prices were drawn from the American Gas Foundation's Renewable Natural Gas Supply Assessment (2025).

Cost data sources include:

- VA residential and commercial code upgrade costs along with NC residential and commercial figures from PNNL code cost-effectiveness studies.
- Green buildings code costs from Phius, Home-Cost, Built Environment Plus, and BR+A, and RSMeans.
- Historical natural gas, electricity, and other fuel prices from EIA reports.
- Projected growth rates for fuel and electricity prices in the South Atlantic region from the EIA Annual Energy Outlook 2025 report.

B3: Increase energy efficiency in existing commercial and industrial buildings through financial incentives and educational outreach programs.

Separate approaches were used to evaluate emission reductions and costs from the following sources: existing commercial buildings, new commercial buildings, and industrial buildings. The methodologies for each are described in the sections below.

GHG Methodology

Existing Commercial Buildings

Potential GHG emission reductions from increasing energy efficiency retrofits in commercial buildings were quantified using NREL's SLOPE Scenario Planner. The analysis scaled down state-level energy consumption outputs from SLOPE's BAEE scenario, which uses NREL's Scout Core Measures Scenario Analysis to model adoption of both commercially available and emerging high-efficiency equipment and building envelope technologies across U.S. residential and commercial buildings.

The Scout model quantifies site-level energy savings by comparing efficient technologies to baseline equipment across major end uses, including space heating, cooling, water heating, and lighting. It assumes that building energy efficiency increases over time as consumers adopt aggressive energy conservation measures that reduce direct fuel use in buildings. Additionally, end-use electrification is projected to increase over time due to a combination of technology cost and performance improvements as well as incentives under the IRA.

National-level results from Scout were first disaggregated to the state level based on state level projections of energy efficiency potential from EPRI. Statewide results for Virginia and North Carolina were then scaled to the Hampton Roads MSA using county population shares. Reductions in commercial electricity and fuel use were calculated relative to the reference case and scaled to the BAU scenario. Energy savings in municipal and school buildings were subtracted from reported totals to avoid double counting with Measure B1.

Key assumptions include:

- The SLOPE BAEE scenario was assumed to reasonably approximate the scale of achievable energy efficiency improvements in the Hampton Roads MSA by 2050. This model assumes that energy efficiency of commercial buildings increases over time, consistent with consumers pursuing aggressive energy conservation measures, including equipment, envelope, and other efficiency improvements that reduce direct fuel use in buildings. End-use electrification is also assumed to grow over time due to a combination of technology cost and performance improvements as well as incentives from the IRA.
- Modeled state-level energy efficiency potentials for Virginia and North Carolina were assumed to be representative of trends within the Hampton Roads MSA.
- Natural gas, fuel oil, and propane use were assumed to decrease proportionally to changes in non-electric fuel use under the BAEE scenario.

Limitations include:

- SLOPE outputs are modeled at the state level and may not capture local variations in housing stock characteristics, climate conditions, income levels, or program participation rates across the Hampton Roads MSA.
- The analysis does not account for implementation barriers such as limited consumer awareness, upfront cost constraints, or workforce availability, which may affect the scale and timing of adoption.

Data sources include:

- NREL Slope Scenario Planner to estimate state-level change in energy consumption under the Best-Available Energy Efficiency in Buildings scenario.

- US Census to estimate each county's share of its state population in 2022, used to scale statewide results to the Hampton Roads MSA.
- City of Richmond's Citywide and Municipal GHG Inventories to estimate the share of total commercial energy consumed by municipal buildings. Richmond's publicly available dataset was used as a proxy for localities in the region to determine the share of the commercial sector that could be attributed to municipal buildings.

New Commercial Buildings

Potential GHG emission reductions from developing energy-efficient and primarily electric new commercial buildings were quantified based on projected improvements in state building energy codes and expanded building electrification. Modeling assumed that Virginia and North Carolina adopt updates to ASHRAE 90.1 and IECC standards every six years through 2050, with code compliance assumed for all new buildings based on a 30-year measure life. New building growth projections were based on available forecasts for the region. A fossil fuel phase-out is assumed to begin in 2040, with a portion of new commercial buildings meeting a green building standard beginning in 2026.

Key assumptions include:

- Energy code compliance was assumed for all new buildings based on a 30-year measure lifetime.
- Updated IECC and ASHRAE 90.1 standards are adopted every six years.
- Commercial construction growth was based on population projections scaled to historical commercial growth, with square footage estimates sourced from NREL ComStock data.
- The green buildings standard corresponds to an ENERGY STAR Portfolio Manager score of 90, representing all-electric buildings meeting a 28.4 kBtu/ft^2 site EUI, decreasing in line with code progression. Adoption increases from 1% of new commercial square footage in 2026 to 25% by 2050.
- Electrification rates follow historical trends until the fossil fuel phase-out for new commercial buildings begins in 2040.

Limitations include:

- New buildings projections are heavily dependent upon commercial square footage growth rates. Changes to these rates will correspond to similar changes in emissions reductions. Commercial square footage growth rates were estimated based on population growth across the region. More detailed studies into labor growth, including the types of projected employment and their correspondence to commercial building growth may give a more accurate estimation of square footage growth.
- New buildings modeling is simplified by only accounting for the fuel usage and EUI per commercial square foot. In actuality, there are many different types of commercial buildings (offices, hospitals, schools, industry, etc.) that the modeling cannot reasonably account for. As such, deviations in energy usage based on the growth rates of different types of buildings are to be expected. EUI is also a simplified annual metric that does not take into account specific building equipment types. The modeling assumed that increases in equipment efficiencies are expected to continue, but future energy consumption may be higher if this assumption changes (such as due to state/federal policies, economic/technological limitations, or other barriers).

Data sources include:

- Growth projections for commercial square footage are drawn from the Weldon Cooper Center for Public Service, the North Carolina Office of State Budget and Management, and NREL's ComStock dataset.
- Energy usage based on data from PNNL cost-effectiveness studies for VA IECC and ASHRAE codes along with NC IECC and ASHRAE codes, Passive House standards, and ENERGY STAR estimates.
- Heat pump efficiency growth from NREL's 2018 Electrification Futures study.

Industrial Buildings

Potential GHG emission reductions from energy efficiency improvements and electrification of industrial buildings within the Hampton Roads MSA were estimated by integrating facility-level data from EPA's GHGRP with industry-average energy use and fuel consumption data from EIA's Manufacturing Energy Consumption Survey (MECS).

Facility-level stationary combustion emission data from GHGRP were converted into primary energy use by fuel and end use (boilers, process heat, and building systems), then modeled to reflect the impacts of replacing fossil fuels with electricity and improving system efficiency.

GHG reductions were quantified by applying electrification and efficiency adoption rates consistent with the U.S. DOE's Industrial Decarbonization Roadmap, which outlines sector-specific pathways for varying levels of technology adoption. These adoption rates represent technology deployment for low-temperature heat, efficient motors and drives, process electrification, and building-related systems such as heating, ventilation, and air conditioning (HVAC) and lighting. Efficiency factors for electrified technologies were drawn from the American Council for an Energy-Efficient Economy (ACEEE), and CO_2 emissions factors for electricity consumption were applied using the BAU grid scenario.

Statewide results were allocated to the Hampton Roads MSA using Bureau of Labor Statistics (BLS) employment data for industrial subsectors as a proxy for local activity. This scaling approach captures the MSA's concentration of energy-intensive facilities associated with shipbuilding, maritime logistics, and advanced manufacturing, as well as smaller-scale fabrication and repair operations.

Key assumptions include:

- The Advanced pathway was used for Hampton Road's policy case scenario, representing accelerated adoption of advanced heat pumps, resistance heating, and electric boilers.
- Grid carbon intensity was assumed to decline in line with the BAU electric power projections for Virginia.
- IP emissions (non-combustion) were excluded to avoid double counting with the Industrial Processes sector.

Limitations include:

- The frameworks used primarily reflect state-level and national data and may not fully capture the energy intensity and technology readiness of individual Hampton Roads industries, particularly shipyards, port facilities, and defense contractors. Barriers such as upfront capital costs, retrofit downtime, and workforce availability were not modeled explicitly but may influence real-world adoption.

Data sources include:

- EPA GHGRP (2022) facility-level emissions (Subparts C, H, and Q)
- EIA Manufacturing Energy Consumption Survey (MECS) (2018)
- DOE Industrial Decarbonization Roadmap (2022)
- DOE Industrial Decarbonization Liftoff Report (2023)
- ACEEE Industrial Efficiency Technical Reference (2023)
- BLS County Employment Data (2024)

Cost Approach

Existing Commercial Buildings

Demand-side system costs from NREL's SLOPE tool were used to quantify the costs of implementing energy efficiency upgrades in existing commercial buildings. These include both the upfront investments required to install efficient equipment (capital costs) and the long-term impacts on customer utility bills resulting from changes in electricity and fuel consumption (operational costs). Relative to the BAU scenario, accelerating the adoption of building efficiency upgrades increases near-term

capital expenditures. In contrast, operational costs show net savings over time, driven by reduced energy consumption from efficiency improvements that accumulate throughout the study period. As shown in Table B14, cumulative total costs are negative across the projection horizon, reflecting long-term bill savings that exceed incremental capital investments.

Consistent with the GHG modeling approach, state-level system costs from SLOPE's BAEE scenario were scaled down using each county's share of its state population. For the commercial sector, capital costs were allocated based on relative costs per megawatt-hour saved from non-residential energy efficiency programs reported in Dominion Energy's Evaluation, Measurement, and Verification Report. Fuel consumption costs were allocated according to the commercial sector's share of total annual fuel and electricity savings. Costs for municipal buildings were subtracted from the reported totals to avoid double counting with Measure B1.

Table B14 presents costs for existing and new commercial buildings. Operational costs also include RNG-related costs, estimated by multiplying annual RNG consumption by the median price reported in the American Gas Foundation's Renewable Natural Gas Supply Assessment. These estimates reflect only the commodity purchase cost of RNG.

Table B14: Measure B3 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	32.93	25.88	3.45	2.88	(2.35)	439.74
Existing Commercial Buildings	-	33.56	29.17	8.94	10.95	5.43	545.22
New Commercial Buildings	-	(0.63)	(3.29)	(5.50)	(8.08)	(7.79)	(105.48)
Operational Costs	2.71	(58.39)	(69.54)	(71.85)	(86.59)	(91.08)	(1,688.23)
Existing Commercial Buildings	2.71	(58.26)	(68.76)	(70.03)	(82.95)	(85.34)	(1,640.07)
New Commercial Buildings	-	(0.14)	(0.78)	(1.82)	(3.64)	(5.74)	(48.16)
Total Costs	-	12.75	31.85	56.74	71.52	86.35	1,120.53
Industrial Buildings	-	12.75	31.85	56.74	71.52	86.35	1,120.53
Total Costs	**2.71**	**(12.70)**	**(11.81)**	**(11.67)**	**(12.19)**	**(7.08)**	**(127.96)**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $(127.96)

Cost data sources include:

- NREL Slope Scenario Planner to estimate state-level system costs under the Best-Available Energy Efficiency in Buildings scenario.
- US Census to scale statewide results to the Hampton Roads MSA.
- Dominion Energy's Evaluation, Measurement, and Verification Report to estimate costs per MWh saved from Dominion's residential and non-residential energy efficiency programs, used to allocate the share capital costs attributable to commercial building retrofits.

New Commercial Buildings

For new buildings, costs were estimated for both upfront costs and operational costs (reflecting energy usage change). Cost results for new commercial buildings are shown in Table B14.

Upfront costs were split between code improvements and additional stretch/green buildings code costs. The upfront cost calculations for implementing energy efficiency through code improvements were extrapolated based on the costs and savings estimated in the most recently available PNNL cost-effectiveness studies. For residential buildings, this was IECC 2021 in VA and IECC 2018 in NC; for commercial buildings, ASHRAE 90.1 2019 was used. These costs estimates were multiplied by the number of residential homes (single and multifamily) or commercial square footage in each city/county to reach the totals.

To reflect the additional costs of a stretch/green buildings code, new residential buildings meeting this additional standard were modeled to achieve Passive House EUI requirements. Costs for Passive House implementation were sourced from Passive House Institute U.S. ("Phius") cost data research, with state new construction cost estimates sourced from Home-Cost. New commercial buildings were modeled to meet EUI standards corresponding to a Portfolio Manager ENERGY STAR score of 90 for the low scenario and the 2019 ASHRAE Advanced Energy Design Guide for Small to Medium Office Buildings - Zero Energy report for the high scenario, with cost estimates derived from studies by Built Environment Plus and BR+A, along with construction cost estimates from RSMeans.

Energy cost savings from new buildings were calculated based on changes in fuel and electricity consumption relative to baseline code-compliant construction. Electricity and fuel prices were sourced from EIA and escalated using growth rates from EIA's Annual Energy Outlook 2025 (Table 3).

Cost data sources include:

- VA residential and commercial code upgrade costs along with NC residential and commercial figures from PNNL code cost-effectiveness studies.
- Green buildings code costs from Phius, Home-Cost, Built Environment Plus, and BR+A, and RSMeans.
- Historical natural gas, electricity, and other fuel prices from EIA reports.
- Projected growth rates for fuel and electricity prices in the South Atlantic region from the EIA Annual Energy Outlook 2025 report.

Industrial Buildings

Costs associated with the GHG reductions modeled for the industrial sector were calculated using marginal abatement cost data from DOE's Pathways to Commercial Liftoff: Industrial Decarbonization report. For each industry type represented within the Hampton Roads MSA, applicable abatement levers such as electrification of thermal systems, energy efficiency improvements, process emission reductions, and low-carbon fuel switching were assigned representative costs per metric ton of CO_2e reduced. These values were weighted based on each subsector's emissions profile and the relative contribution of each intervention to total modeled abatement potential, resulting in a weighted average lifecycle cost of abatement ($/MTCO$_2$e) for each industrial subsector as shown in Table B15.

Table B15: Average Cost of Abatement by Industrial Subsector ($/MTCO$_2$e)

Industrial Sector	Weighted Average Cost ($/MTCO$_2$e)
Light Industry (Food, Beverage, Tobacco, Transport & Warehouse, Educational Services, Public Administration)	57.42
Paper & Pulp	34.33
Minerals/Cement	31.12

Examples of capital costs include the incremental expense of replacing fossil fuel systems such as boilers, furnaces, and direct-fired process heaters with electric technologies like heat pumps, resistance, or induction systems, as well as upgrades to motors, compressors, controls, and HVAC equipment. Operational cost impacts reflect modeled energy savings and the transition from fossil fuels to electricity or other low-carbon fuels.

Total abatement costs were estimated by multiplying the weighted cost per $MTCO_2e$ by the emissions reductions modeled in CO_2Sight under the mitigation scenario. The resulting values represent the combined cost of implementing a diverse set of industrial decarbonization strategies, inclusive of electrification, efficiency, process improvements, and fuel switching.

In many cases, stationary and process emissions in industrial facilities often originate from the same equipment, such as furnaces, boilers, and other thermal systems. A single upgrade often reduces both types of emissions at the same time. When a system is electrified, retrofitted, or replaced with a low carbon fuel alternative, it simultaneously reduces both combustion-related and process emissions connected to that equipment. For this reason, costs for Measures B3 and I1 were bundled to avoid double counting and to reflect that one intervention typically delivers both sets of emission reductions.

Total cost results for Measure B3 are presented above in Table B14. Table B16, below, disaggregates costs for industrial stationary and process emissions by industrial subsector.

Table B16: Industrial Subsector Annual and Cumulative Implementation Costs (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Light Industry	-	10.45	26.10	46.50	58.61	70.77	918.27
Paper and Pulp	-	1.65	4.11	7.32	9.23	11.15	144.64
Mineral	-	0.66	1.64	2.92	3.68	4.44	57.62
Total Costs	**-**	**12.75**	**31.85**	**56.74**	**71.52**	**86.35**	**1,120.53**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $1,120.53

Cost data sources include:

- DOE Industrial Decarbonization Liftoff Report (2023)
- DOE Industrial Decarbonization Roadmap (2022)
- EIA Annual Energy Outlook 2025 report
- NREL Annual Technology Baseline 2024
- EPA GHGRP (2022) facility-level emissions
- BLS County Employment Data (2024)

Renewable Natural Gas

RNG was used in the building and industrial sectors to reduce the carbon intensity of remaining gas consumption. RNG can serve as a direct substitute for fossil gas either via direct use onsite or through a book-and-claim process whereby the credits for the carbon attributes are transferred to the assets using them. While not included as a standalone measure, RNG was incorporated as an additional modeling component to support progress toward the MSA's net zero emissions targets. For the purposes of this modeling, RNG was applied to fuel use in the buildings sector. Overall, RNG is projected to avoid 14.34 $MMTCO_2e$ from 2025 through 2050, with these emission reductions accounted for under the buildings sector measures.

GHG Methodology

RNG integration is designed to further the decarbonization goals of the Hampton Roads region by replacing existing fossil fuel gas usage with zero-emission RNG. For modeling purposes, RNG (produced via a combination of anerobic digestion and thermal gasification) was assumed to be blended into the region's pipeline gas and used in the residential, commercial, and industrial settings. Similar to SAF and renewable diesel, RNG was modeled using a lifecycle emissions factor and is treated as carbon neutral from a Scope 1 perspective.

Key assumptions include:

- RNG was used as a direct replacement for fossil gas and treated as a zero-emissions fuel.
- RNG estimates were sourced from the American Gas Foundation's 2025 Renewable Natural Gas Supply Assessment report. This report details annual state-level supply of RNG from 2025-2050 under three scenarios, using eight different feedstock types. The modeling reflected use of the report's "Ambitious Emission Reduction" scenario.
- The modeling resulted in a blended pipeline gas emissions factor across Virginia, which was used for the Hampton Roads region as a simplifying assumption.
- The BAU scenario does not include any RNG within the energy system.

Limitations include:

- All RNG in this modeling was assumed to emit only biogenic carbon dioxide and thus be carbon free from a Scope 1 accounting perspective. Actual lifecycle RNG emissions depend on the feedstock and range from 150g CO_2e/MJ to -70g CO_2e/MJ.
- The modeling considered Virginia's in-state RNG production capacity as a proxy for total usage, which was then allocated down to the Virginia and North Carolina counties in the Hampton Roads region through pipeline blending. In reality, the state as well as the Hampton Roads region will have access to a wider array of regional RNG production sources, but will also need to compete with other states, regions, and private entities in order to source this supply.
- The BAU case was assumed to not use RNG, which was a simplifying assumption made for ease of integration that reflects the current low levels of adoption.
- While RNG is a mature technology, implementation at the scale outlined is currently constrained by economic factors. RNG is not broadly cost competitive compared to fossil gas. To achieve full deployment of the fuels, policies may be needed for further economic support.

Data sources include:

- American Gas Foundation's Renewable Natural Gas Supply Assessment (2025)

Cost Approach

RNG costs are accounted for within the buildings and industrial sector measures (Table B13 and Table B14). These costs were estimated by multiplying annual RNG consumption by the median price reported in the American Gas Foundation's Renewable Natural Gas Supply Assessment. The estimates reflect only the commodity purchase cost of RNG.

Cost data sources include:

- American Gas Foundation's Renewable Natural Gas Supply Assessment (2025)

Energy Supply

These measures quantify potential GHG reductions from strategies that decarbonize the region's electricity supply, including transitioning the grid toward cleaner energy sources and promoting local rooftop solar deployment. All modeled emission reductions are attributed to the expansion of rooftop solar, as no additional actions beyond the BAU scenario were modeled for measure E2. Overall, emissions from this sector are projected to decrease by 4.56 $MMTCO_2e$ from 2025 through 2050.

Table B17: Summary of Energy Supply Sector CCAP Measure GHG Reductions ($MMTCO_2e$)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub	0.68	4.56
Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency	NE	NE

E1: Accelerate regional solar energy adoption by expanding program participation, streamlining permitting and increasing community awareness and education through a Solar Hub

GHG Methodology

This measure quantifies the potential GHG reductions associated with increased local grid-connected and rooftop solar deployment in the MSA. This measure builds from existing progress in the region. Beyond GHG emission reductions, solar – particularly onsite systems paired with battery storage – can help lower household energy bills and increase resiliency to grid outages. By 2050, the MSA has about 1.1 GW of installed solar capacity, up from 0.1 GW in 2024.

The modeling for this measure is based on NREL datasets identifying rooftop solar technical potential by state, NREL reports on market and economic adoption potential, and estimates of rooftop square footage area for residential and commercial buildings by county from NREL's ResStock and ComStock datasets.

The modeling process to assess solar adoption uses data on 1) rooftop area available for solar, 2) solar output potential and 3) the adoption rate.

- The available rooftop area is from NREL's 2016 Rooftop Potential Study, which includes state-level roof area suitable for solar for residential (small) and commercial (medium-large) systems. This is downscaled to the county level using rooftop area for residential and commercial buildings from NREL's ResStock and ComStock datasets.
- The NREL dataset also provides the kW/m^2 solar output potential for the roof area.
- Using the county rooftop area and solar output potential, NREL defines a technical potential for rooftop solar. NREL DG Solar and Storage Outlook, EFS 2021 provides adoption scenarios. The aggressive "Advanced PV + Battery" adoption scenario was selected, which achieves a 20% adoption rate (of technical potential) as an average across the MSA, and battery storage equivalent to about 7% of solar capacity.
- The avoided emissions from solar were estimated based on the grid emissions factor.

Limitations include:

- Using the NREL data and adoption rate for rooftop solar is an imperfect proxy to estimate the potential for solar growth in the region. In reality, systems will have varying sizes, and large (>20 MW) front-of-the-meter installations can increase the pace of solar deployment compared to residential rooftop installations (which average 7-8 kW per home).
- Actual adoption rates will be influenced by a range of factors, including the cost-effectiveness of solar installations, the efficiency of permitting and regulatory approval processes, and the ease of grid interconnection. Ongoing market uncertainties—such as fluctuations in clean energy tax incentives, tariffs, and broader economic conditions—will play a significant role in determining the real-world impact of this measure.

Data sources include:

- NREL's 2016 Rooftop Potential Study
- NREL DG Solar and Storage Outlook, EFS 2021
- EIA RECS and CBECS
- NREL ResStock and ComStock

Cost Approach

To estimate the cost of deploying solar, NREL's 2024 Annual Technology Baseline was used for forecasts of capital and operating costs for residential and commercial distributed solar systems. These costs were applied to the incremental capacity added in each year of the forecast. These costs were applied to the incremental new capacity added in each year of the forecast. In addition, potential bill savings were estimated based on electricity retail rates from EIA-861, which were projected through 2050 based on EIA's Annual Energy Outlook (AEO) trends. The bill savings drive significant potential for lower costs with rooftop solar due to lower electricity bills. Bill savings are a key driver for the payback period for rooftop solar systems, which can range from 5-15 years depending on the system size and electricity rate.

Table B18: Measure E1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	35.12	28.56	25.89	23.23	20.57	709.07
Operational Costs	-	2.39	3.69	4.95	5.95	6.69	106.70
Bill Impacts (Avoided Costs)	-	(20.86)	(40.66)	(57.29)	(79.08)	(98.87)	(1,293.27)
Total Costs	-	**16.66**	**(8.42)**	**(26.45)**	**(49.90)**	**(71.62)**	**(477.50)**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $(477.50)

Cost data sources include:

- 2024 NREL Annual Technology Baseline for moderate scenario capital expenditure (CAPEX) and fixed O&M costs for residential and commercial distributed solar resources
- EIA-861 for average 2024 residential and commercial retail electricity rates in VA and NC
- EIA AEO 2025 Table 3.5 for projected growth rates of electricity prices in the South Atlantic region

E2: Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency

GHG Methodology

In the BAU scenario, grid electricity emission factors for Virginia counties were based on Virginia State CPRG modeling, reflecting the VCEA mandate for utilities to achieve net zero emissions by 2050. For North Carolina counties, emission factors were derived from EIA AEO 2023 (Table 54.13) projections. In both cases, no additional actions beyond the BAU scenario were modeled.

Cost Approach

Costs were not quantified for this measure.

IPPU and Ports

These measures model GHG emission reductions from strategies that lower emissions from both industrial processes and port operations. Collectively, these measures are projected to reduce emissions by 6.06 $MTCO_2e$ from 2025 through 2050.

Table B19: Summary of Industry Sector CCAP Measure GHG Reductions ($MMTCO_2e$)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Support emissions reductions from industrial processes	0.31	4.90
Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes	0.12	1.16

I1: Support emissions reductions from industrial process

GHG Methodology

Process emissions result from the chemical and physical transformations inherent to industrial production, such as fermentation, calcination, chemical pulping, or glass melting, that release CO_2 independent of fuel combustion. In this analysis, total process emissions were reduced by 30% by 2050 to represent the cumulative impact of feasible technology and material interventions across key industrial subsectors. These reductions reflect improvements in production efficiency, material substitution, and emissions capture rather than structural shifts in output or activity.

Key assumptions include:

- A uniform 30% reduction in process emissions was applied across all modeled industries to represent a conservative estimate of achievable reductions by midcentury.
- Modeled reductions reflect the cumulative impact of practical interventions that can scale within existing industrial systems, such as increased recycling, process optimization, and feedstock substitution that lowers inherent CO_2 generation.
- For the minerals sector (e.g., glass), reductions were attributed to increased cullet use in glass manufacturing and efficiency improvements from advanced furnace technologies like oxyfuel systems.

- For the pulp and paper sector, reductions stemmed from enhanced chemical recovery, greater fiber recycling, and operational improvements that reduce chemical demand and waste generation.
- Process emissions in light industry and food and beverage are relatively small; modest reductions were applied to capture improved process controls and the phaseout of high-global-warming-potential refrigerants.
- Production volumes were held constant across sectors, and reductions result solely from technological and material improvements rather than changes in industrial output.

Limitations include:

- The use of a single reduction factor does not capture variability in process design, technology readiness, or site-level abatement potential.
- Process-level data are limited across many subsectors, and some reduction pathways remain at early commercial or pilot stages.
- Reductions were modeled as linear through 2050 and do not reflect timing or sequencing of technology adoption.
- Non-CO_2 process gases (e.g., CH_4, N_2O) were excluded from process-specific modeling.

Data sources include:

- U.S. DOE. Industrial Decarbonization Roadmap. Office of Energy Efficiency and Renewable Energy, 2022.
- U.S. DOE. Pathways to Commercial Liftoff: Industrial Decarbonization. Loan Programs Office, 2024.
- U.S. EPA. GHGRP, 2023 Data Summary.

Cost Approach

The costs for process emission reductions are bundled with Measure B3.

I2: Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes

GHG Methodology

The Port of Virginia's sustainability plan commits the port to achieving net-zero carbon emissions by 2040, the most aggressive timeline among major U.S. East Coast ports. The plan is built on two primary strategies for eliminating GHG emissions: replacing diesel-powered cargo handling equipment with zero-emission electric and hybrid-electric alternatives to reduce Scope 1 emissions and by sourcing 100% of the port's operational electricity from clean, renewable resources to reduce Scope 2 emissions. Given that the Port has already developed a detailed decarbonization pathway to reach its 2040 target, the modeling leverages assumptions and data from the Port of Virginia's 2024 Sustainability Report to project fuel and electricity consumption for port operations within the region.

GHG emission reductions were modeled based on potential decarbonization projects at port facilities within the Hampton Roads MSA. The analysis considered equipment and system upgrades, including replacements for forklifts, vans, cruisers, shuttles, pickups, buses, and deployment of battery energy storage systems. Diesel-powered equipment was assumed to be replaced with zero-emission battery-electric units, with associated emission reductions estimated using EPA's Diesel Emissions Quantifier tool.

Key assumptions include:

- Two battery energy storage systems (12 MW and 5 MW) were modeled, reflecting typical peak-shaving applications and assuming full utilization during modeled periods.
- Port terminals were assumed to operate 360 days per year, consistent with standard port activity levels.
- Replacement equipment is fully electric and provides equivalent service capacity to diesel units.

Limitations include:

- Limited publicly available operational data required a high-level assessment of emission reductions and costs.
- The modeling reflects representative port configurations and may not capture all site-specific equipment or duty cycles.
- The DEQ tool uses generalized emission factors that may not fully reflect Hampton Roads-specific fleet composition or operations.

Data sources include:

- Port of Virginia 2024 Sustainability Report
- U.S. Army Corps of Engineers Entrances and Clearances Data
- U.S. Army Corps of Engineers Waterborne Cargo and Trips Data Files
- Port of Los Angeles Inventory of Air Emissions (2021)
- EPA Diesel Emissions Quantifier (DEQ)

Cost Approach

Costs were evaluated using findings from the Port of Virginia's Decarbonization Strategy and Implementation Report, which developed a high-level cost model for assessing decarbonization initiatives across the state's port facilities. The analysis incorporated asset procurement costs (e.g., vehicle and equipment purchases), operations and maintenance costs associated with fleet operations, energy costs for fuel and electricity use, and infrastructure costs such as charging equipment upgrades.

In 2025 dollars, reported costs were equivalent to $272 in capital costs per $MTCO_2e$ avoided and $394 in operational costs per $MTCO_2e$ avoided. These unit cost assumptions were applied to the modeled emission reductions to estimate total implementation costs for decarbonizing ports within the MSA. Table B20 summarizes the annual and cumulative implementation costs for this measure.

Table B20: Measure I2 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Capital Costs	-	7.53	10.10	14.01	17.39	21.58	315.87
Operational Costs	-	10.92	14.66	20.34	25.24	31.32	458.51
Total Costs	**-**	**18.45**	**24.76**	**34.35**	**42.63**	**52.90**	**774.37**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $774.37

Cost data sources include:

- Port of Virginia's Decarbonization Strategy and Implementation Report, an internal study provided by the Virginia Port Authority

Waste and Wastewater

GHG reductions were quantified from the two waste sector measures, which include actions to reduce landfill emissions and improve the energy efficiency of wastewater treatment processes. Collectively, these measures are projected to decrease emissions by 1.48 $MMTCO_2e$ from 2025 through 2050.

Table B21: Summary of Waste and Wastewater Sector CCAP Measure GHG Reductions (MMTCO2e)

Measure	Cumulative 2025-2030 GHG reductions	Cumulative 2025-2050 GHG reductions
Divert recyclable and compostable waste from landfills	0.005	1.37
Support efficiency upgrades at wastewater treatment plants	0.001	0.11

W1: Divert recyclable and compostable waste from landfills

GHG Methodology

The methane commitment method from the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) was applied to calculate GHG reductions from diverting organics and recyclable waste. The percentage of waste diverted to recycling and composting was derived from historical statewide waste disposal data, and a waste characterization study was used to determine the share of landfilled waste that is recyclable and compostable.

Waste diversion was assumed to begin in 2030, increasing linearly from 0% in 2029 to 80% in 2050. These diversion rates were applied to calculate annual tonnage of recyclable and compostable material diverted from landfill disposal. The resulting diverted tonnage values were then used as inputs to the GPC methane commitment equation to estimate emissions under the measure scenario.

Key assumptions include:

- Waste diversion rates increases linearly from 0% diverted in 2029 to 80% diverted in 2050.

Limitations include:

- This methodology does not calculate the added emissions due to increased composting and recycling.

Data sources include:

- GPC methane commitment method

Cost Approach

For organic waste diversion, the ReFED Solutions Database was used to acquire data specific to Virginia and North Carolina, to determine annual diversion potential in tons and annual GHG reduction potential in $MTCO_2e$. Three action types from the database were used in the cost analysis: 1) Recycle Anything Remaining, 2) Reshape Consumer Environments, and 3) Strengthen Food Rescue. Each action type contributes a different share to the overall diversion potential. Recycle Anything Remaining contributes 32%, Reshape Consumer Environments contributes 62%, and Strengthen Food Rescue contributes 6%. Each action has a different cost per metric ton of GHG reduced, ranging from $19 to $496, depending on the strategy and the state. Finally, the weighted average cost per metric ton of GHG reduced was calculated, using the diversion share and cost per ton GHG for each action for each state. The result per ton for the average implementation cost for diverting one ton of organic waste was $124.22 for Virginia and $146.90 for North Carolina. The implementation cost was applied to each jurisdiction's waste

diverted quantity. For the baseline recycling cost reference, a unit cost of $126 per ton of recycling was used as a reference, based on the NYC Independent Budget Office (2017).

Table B22: Measure W1 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Recycling	-	2.45	14.94	27.92	41.60	55.99	596.71
Organic Waste Diversion	-	0.01	0.51	1.75	3.79	6.70	49.12
Total Costs	**-**	**2.46**	**15.45**	**29.67**	**45.40**	**62.69**	**645.82**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $645.82

Cost data sources include:

- NYC Independent Budget Office Recycling Cost
- Federal Reserve Bank of St. Louis Table Data – Gross Domestic Product: Implicit Price Deflator.
- ReFED Solutions Database

W2: Support efficiency upgrades at wastewater treatment plants

GHG Methodology

To calculate GHG reductions from wastewater treatment plants, EPA's State-Level Non-CO_2 Greenhouse Gas Data Tool was used to identify the potential for methane and nitrous oxide reductions in Virginia and North Carolina. A percentage reduction potential was calculated for each state, with reductions assumed to begin in 2030 and increase linearly to reach the full reduction potential by 2050.

This quantification approach is limited by the lack of facility-specific wastewater treatment data for Virginia and North Carolina. As a result, it is uncertain whether the full reduction potential identified in EPA's tool can be feasibly achieved by wastewater treatment plants in the MSA.

Key assumptions include:

- State-level methane and nitrous oxide reduction potentials from EPA's tool are representative of wastewater treatment facilities within the MSA.
- Emission reductions begin in 2030 and increase linearly through 2050.
- Reduction technologies and operational practices assumed by EPA are technically feasible and available to MSA wastewater treatment plants over the study period.

Limitations include:

- Lack of facility-specific data for wastewater treatment plants in Virginia and North Carolina may lead to over- or under-estimation of actual reduction potential.
- EPA's reduction potentials may not fully reflect local treatment technologies, plant sizes, or operational conditions within the MSA.
- Actual implementation timelines may differ due to funding, permitting, or technology deployment constraints.

Data sources include:

- EPA's State-Level Non-CO_2 Greenhouse Gas Data Tool

Cost Approach

Costs were calculated by applying the unit cost per metric ton of CO_2e reduced, as reported in EPA's State-Level Non-CO_2 Mitigation Potential, to the estimated emission reductions.

Table B23: Measure W2 Annual and Cumulative Cost of Implementation (2025$ Million)

	2025	2030	2035	2040	2045	2050	2025-2050
Total Costs	**-**	**0.64**	**3.88**	**7.24**	**10.79**	**14.51**	**154.71**

Cumulative Cost of Implementation from 2025-2050 (Million 2025 USD): $154.71

Cost data sources include:

- EPA's State-Level Non-CO_2 Greenhouse Gas Data Tool

Co-Pollutant Quantification Methodology

National Emissions Inventory (NEI) 2022 Inventory

The EPA NEI 2022 serves as the foundational dataset for constructing the emissions inventory and developing BAU projections across the Hampton Roads MSA. The workflow integrates EPA's National Emissions Inventory data, crosswalked to U.S. Greenhouse Gas Inventory categories, and extended through 2050 using consistent, category-level growth assumptions from NEI projections. The mapping to inventory sector categories was informed by EPA.

Table B24: Co-Pollutant Emissions by Sector and Pollutant

Category	CO	NO_x	VOC	PM_{10}	$PM_{2.5}$	SO_2	NH_3
Agriculture	12,958	1,651	82,254	5,440	1,693	65	5,204
Industrial Process	1,424	1,674	17,718	6,672	1,975	637	10
Mobile Transportation	128,551	18,352	11,054	1,336	791	322	852
Stationary (e.g., Buildings)	13,638	4,439	1,634	4,059	3,679	269	316
Waste	6,642	484	908	954	864	177	380
Other	452	11	114	4,974	939	1	-
TOTAL	**163,664**	**26,610**	**113,682**	**23,434**	**9,940**	**1,470**	**6,762**

Co-Pollutant Quantification Approach by Sector

Criteria Air Pollutants (CAPs) were quantified because they are common pollutants with widespread public health impacts, causing respiratory and cardiovascular diseases, asthma aggravation, and premature death. Their reductions are linked to clear public health benefits and regulatory air quality standards, supported by well-established emissions factors and monitoring methods. CAPs include ozone, particulate matter ($PM_{2.5}$, PM10), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and lead.

Hazardous Air Pollutants (HAPs), in contrast, tend to be emitted in smaller quantities with more complex sources and lack widely available emissions factors, making their reductions harder to quantify and often smaller in overall impact. For this report, CAP impacts from each sector were prioritized to address broad public health protection, while HAP reductions may not show significant measurable changes. HAPs include over 180 chemicals including benzene and mercury making them harder to quantify.

Although HAPs are not quantitatively represented, they will still be reduced through GHG reduction measures. Reducing energy use in buildings by increasing efficiency and transitioning to cleaner energy sources lowers the need for burning fossil fuels, which in turn can decrease emissions of toxic air pollutants like formaldehyde, benzene, and other hazardous substances. When more EVs are used and VMT decrease, emissions of hazardous air pollutants from gasoline and diesel engines, such as 1,3-butadiene, acetaldehyde, and benzene, are also reduced. These shifts generally improve both outdoor and indoor air quality, lessen the public's exposure to a variety of indoor and outdoor toxins, and support better respiratory and overall health outcomes, particularly in densely populated or heavily trafficked areas.[46]

Buildings

For energy efficiency or fuel-switching measures in the buildings sector, less fuel is used in both new and existing buildings. This not only reduces GHG emissions but also decreases emissions of other harmful pollutants that are released during fuel combustion. The following methodology was used to quantify co-pollutant emission reductions in the building sector:

- Quantify Fuel Saved: Determine the amount of each fuel type saved by comparing the baseline scenario to the mitigation scenario.
- Apply Emission Factors: Use standard EPA AP-42 emissions factors for each fuel type to estimate how much NO_x, SO_2, Lead, CO, and PM would have been emitted if the fuel had been used.
- Calculate Emissions Reductions: Multiply the amount of each fuel saved by its corresponding emission factor to estimate the avoided emissions for each pollutant.

Transportation

Co-pollutant reductions were quantified using emission factors derived from 2020 EPA NEI data and VMT estimates. Emission factors were calculated by dividing total 2020 emissions by total 2020 VMT, disaggregated by county, pollutant, vehicle type, and fuel type, resulting in mass per mile (e.g., metric tons CO per diesel truck mile).

For the mitigation scenario, these emission factors were applied to projected VMT through 2050 to estimate gross emissions under the mitigation pathway. Specifically, the emissions factor for each pollutant and vehicle/fuel category was multiplied by the corresponding VMT in the mitigation scenario. The resulting emissions were then subtracted from the 2020 NEI-based BAU emissions to estimate net reductions in co-pollutants attributable to the mitigation strategy.

For aviation, an emissions factor approach was used. Gross emissions reductions were calculated by multiplying the amount of jet fuel saved (from baseline minus mitigation scenario) by Greenhouse gases, Regulation Emissions, and Energy use in

Technologies (GREET) emissions factors for conventional jet fuel. Emissions from SAF were also calculated from GREET factors. The SAF emissions were subtracted from the gross emissions reductions to calculate net emissions reductions.

Waste

Waste reduction measures lead to less waste ending up in landfills. This not only reduces greenhouse gas emissions but also decreases emissions of other harmful pollutants, specifically NO_x, CO, $PM_{2.5}$, and VOC that are released when landfill gas is flared. The following methodology was used to quantify co-pollutant emission reductions in the waste sector:

- Estimate Methane Generation Avoided: how much methane would have been produced by diverted waste if it had been landfilled.
- Apply Emission Factors: standard EPA emission factors were used to estimate how much NO_x, CO, $PM_{2.5}$, and VOC would have been emitted from flaring the methane generated by the landfilled waste.

Natural & Working Lands

Co-pollutant removals were quantified using data from the i-Tree Landscape Module47, accessed by county. Annual pollutant removal estimates were converted from pounds to metric tons and downscaled to a per-tree basis using the total number of trees in the MSA, as quantified in the NWL measure GHG modeling.

These per-tree removal rates were multiplied by the number of new trees projected to be planted across the MSA under the GHG mitigation scenario aggregated by locality. This approach yields cumulative co-pollutant removal estimates attributable to tree planting efforts, representing added benefits from natural sequestration and air quality improvements.

Electricity Demand Changes

Mitigation measures such as building and transportation electrification and solar installations lead to changes in electricity demand. This in turn changes how power plants across the broader regions – within and outside of the MSA – operate. Because the changes in power plants occur across a broader region and not just within the MSA, these co-pollutant emission changes are reported separately, although a portion would likely occur within the region.

Net electricity demand increases with measure implementation of building and transportation electrification, leading to increased co-pollutant emissions. This is a potential disbenefit to communities that live around power plants that increase their output to meet this increased electricity demand and emphasizes the importance of measures focusing on increasing the amount of clean energy capacity deployed.

The net change in co-pollutant emissions across the broader power grid was estimated based on projected changes in the electricity grid mix. These projections were informed by data from EPA's National Emissions Inventory, EIA's form EIA-923, and power sector modeling data from the Virginia State CCAP, which reflect the increased demand.

Factors

The tables below contain the factors and sources used for this analysis.

Table B25: Building and Industry Fuels Emissions Factors

Fuel	Notes	Units	NO_x	SO_2	PM	CO	Lead	VOC
Natural Gas[48]	Source: AP-42, Uncontrolled small boiler or controlled (recirculation) large boiler	Boiler Ef (lb/1000000 scf)	100	0.6	7.6	84	0.0005	5.5
Natural Gas	Source: AP-42, residential furnace	Ef lb/1000000 scf	94	0.6	7.6	40	0.0005	5.5
Natural Gas	Source AP-42 , assume large industrial boiler, low NOx burner	Ef lb/1000000 scf	140	0.6	7.6	84	0.0005	4.69
Fuel Oil[49]	Source: AP 42, <100 MMBTU	Boiler Distillate oil fired Ef (lb/1000 gal)	20	7.1	2	5	0.002	0.46
LPG[50]	Source: AP 42	Propane Ef (lb/1000 gal) Propane Ef (lb/1000 gal)	1313	0.050 .05	0.70.7	7.57 .5	00	0.80.8
Coal	Source: AP 42, spreader stoker, bituminous	common in medium sized boilers, assuming use in industrial buildings (lb/ton)	11.00	76.00	66.00	5.0 0		
Other	These represent a 55/45 split of coal/oil boilers	lb/MMBtu	0.33	1.25	0.14	0.0 3	0.00	0.00

Table B26: Conversion and Heat Factors

Fuel Type	Value	Units	Source
Natural gas	1036	BTU/scf	EIA
Distillate oil heating value	140	MMBTU/1000 gal	EPA
Residual oil heating value	150	MMBTU/1000 gal	EIA
Propane heating value	91.5	MMBTU/1000 gal	EIA

Table B27: Sulfur (S) Content Estimates

Fuel Type	Value	Unit
Assumed S content of distillate oil	0.05	% by weight (500 ppm)
Assumed S content of propane	0.5	% by weight
Assumed S content of 6 oil	0.5	% by weight

Table B28: Aviation Emissions Factors from GREET1 2024[3]

Pollutant	HEFA SAF EF (g/MJ)	Petroleum Conventional Jet EF (g/MJ)
CO	0.06	0.06
NO_x	0.21	0.23
PM10	0.00	0.00
PM2.5	0.00	0.00
SOx	0.00	0.03
VOC	0.01	0.01

Table B29: Waste Emissions Factors from EPA AP-42[4]

Control Device	Source	Units	NO_x	SO_2	PM	CO	Lead	VOC
Flare	EPA AP-42: Emission rates for secondary compounds exiting control devices	Lb/10^6 dscf Methane	40	0	17	750	0	4.1

Benefits Assessment

Implementation of the measures will have a range of co-benefits for the MSA, particularly health benefits from improved air quality. In addition, the NWL sector measures will enhance ecosystem services. This section details the methodology for the quantified monetary and health outcomes from these elements.

Ecosystem Services

Impacts from the natural and working lands sector were derived from the i-Tree landscape model. The i-Tree Landscape module is a web-based tool that spatially estimates ecosystem services provided by trees across different landscapes, such as urban or rural areas. The module uses tree cover data, leaf area index, weather, pollution levels, and local population data to estimate benefits like air pollution removal and stormwater management. Specifically, it quantifies how much air pollutants such as NO_x, SO_2, ozone, CO, and PM are removed by trees, using deposition rates and leaf surface area. It also estimates stormwater runoff reduction by calculating how trees intercept rainfall based on canopy cover and local weather conditions.

Table B30: Total NWL Co-pollutant Removals

Pollutant	Cumulative Removals (MT) (2025-2050)
NOx	42,715
SO2	53,178
PM	124,218
CO	3,920
Lead	0.00

[3] JetFuel_WTWa tab, “Passenger Aircraft, Singl Aisle (SA): HEFA from Soybean” table; JetFuel_WTWa tab, “Passenger Aircraft, Singl Aisle (SA): Petroleum Conventional Jet” table

[4] https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s04.pdf

Table B31: NWL avoided stormwater runoff added monetary benefit of increased tree canopy cover

Region	2050 Monetary Value
Total MSA	$21,531,287

The results highlight the significant co-benefits of natural and working lands investments in the region, both for air quality and water management. Cumulatively, trees are projected to remove hundreds of thousands of metric tons of pollutants including PM, NO_x, SO_2, and CO between 2025 and 2050, improving public health and regional air quality. In addition, expanding tree canopy cover yields substantial economic value for stormwater management, with avoided runoff benefits reaching millions of dollars in several counties. The results show that forest and soil conservation strategies combined with green initiatives provide not only greenhouse gas mitigation but also measurable local benefits in air pollution reduction and infrastructure cost savings.

Health Impacts

The table below presents the cumulative health benefits and associated monetary values resulting from quantified co-pollutant reductions in the MSA between 2025 and 2050. These estimates are derived from the Co-Benefits Risk Assessment (COBRA) model and reflect the total change in incidence, the number of avoided cases, for each health impact category. The monetary benefits represent the economic value of these avoided outcomes, including reduced mortality, fewer hospital visits, and improved productivity through fewer missed school and workdays. This summary provides an MSA-wide overview, which is followed by sector-specific results detailing pollutant reductions and health impacts at a more granular level.

At the MSA level, the table provides a range of estimates, low and high, for both health outcomes and their monetized benefits for mortality. These ranges reflect uncertainty in the underlying epidemiological and economic assumptions, such as the sensitivity of populations to air pollution and the valuation of avoided health outcomes. The low estimate represents a more conservative scenario, while the high estimate assumes stronger health effects and higher economic valuations. This range helps contextualize the potential variability in benefits.

Table B32: Health impact results for the MSA ($2025)

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$2,878,240,633 - $1,466,427,791	197 - 100
Hospital Visits	$1,200,392	214
Missed School/Work or Restricted Activity	$40,884,629	92,145
Cardiovascular Conditions	$4,498,133	61
Respiratory Conditions	$44,123,840	69,167

In the sector-specific results that follow, only the low-end estimates from COBRA are shown. This approach is intended to maintain a conservative and cautious interpretation of the data. By focusing on the lower bound of potential benefits, the analysis avoids overstating impacts while still capturing the meaningful health and economic gains associated with co-pollutant reductions.

Commercial and Residential Buildings

In the buildings sector, the modeled strategies have led to significant cumulative reductions in key pollutants from 2025 to 2050. The buildings sector has the highest cumulative reductions for NO_x. These reductions are primarily driven by a suite of building-focused strategies aimed at improving energy efficiency and electrification.

Table B33: Total commercial and residential buildings co-pollutant reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	11,252
SO_2	417
PM	841
CO	8,393
Lead	0.12
VOC	598

Translated into health impact quantification, using the results provided from COBRA, the building residential sector is estimated to achieve substantial public health benefits between 2025 and 2050. These include avoided mortality valued at approximately $227.6 million, along with reductions in hospital visits, missed school and workdays, cardiovascular conditions, and respiratory conditions.

Table B34: Residential buildings COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$227,584,411	16
Hospital Visits	$154,479	41
Missed School/Work or Restricted Activity	$11,206,488	12,815
Cardiovascular Conditions	$412,354	6
Respiratory Conditions	$10,741,234	13,826

The commercial sector shows strong health co-benefits, with cumulative mortality benefits estimated at $196.1 million, slightly lower than the residential sector. It also shows comparable gains in hospital visits, missed activity days, and respiratory conditions. Across the sector, the incidence reductions reflect consistent annual gains, particularly in respiratory and productivity-related outcomes, reinforcing the sector's importance in air quality and health policy planning.

Table B35: Commercial buildings COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$196,135,586	13
Hospital Visits	$133,461	35
Missed School/Work or Restricted Activity	$9,645,135	11,063
Cardiovascular Conditions	$357,302	5
Respiratory Conditions	$9,247,110	11,911

Industrial Buildings

In the industrial buildings sector, fuel-switching and increased energy efficiency measures reduce the use of high-emission fuels such as fuel oil, propane and coal while increasing reliance on natural gas. While switching from coal to natural gas reduces greenhouse gas and SO_2 emissions, it can increase emissions of carbon monoxide. Increased emissions from CO and VOC reflect the combustion characteristics between natural gas and other fuel types, natural gas burns less CO and VOCs than other fuels included in the industrial buildings sector. These changes are driven by building measures aimed at improving energy efficiency and electrification.

Table B36: Total industrial buildings co-pollutant reductions

Pollutant	Cumulative Changes (MT) (2025-2050)
NO_x	845
SO_2	33,987
PM	3,635
CO	(1,014)
Lead	0.22
VOC	(18)

Note: Negative values indicate net increases in emissions

The industrial buildings sector stands out as the most impactful in terms of net health benefits. It leads all sectors in cumulative monetary benefits across every health category, including mortality, hospital visits, missed school/workdays, cardiovascular conditions, and respiratory conditions This sector results in decreased mortality, hospital visits, missed activity days, and respiratory conditions compared to the BAU scenario. COBRA default baseline values were used for SO_2 from 2030-2050 and PM for 2050 value calculations in COBRA software because calculated reductions exceeded COBRA's default baseline.

Table B37: Industrial buildings COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$864,998,476	59
Hospital Visits	$791,268	104
Missed School/Work or Restricted Activity	$10,479,611	58,197
Cardiovascular Conditions	$3,426,455	47
Respiratory Conditions	$15,100,817	32,032

Note: Negative values indicate net decreases in benefits

Transportation

The largest CO emission reductions come from the transportation sector, specifically from on-road vehicles, due to decreased tailpipe emissions from ZEV adoption.

Table B38: Total transportation co-pollutant reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	4,750
SO_2	1,275
PM	317
CO	31,687
VOC	47

Table B39: On-road transportation co-pollutant reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	2,860
SO_2	43
PM	126
CO	31,299

The majority of NO_x, SO_2, PM, CO, and VOC emission reductions come from the use of SAF in aviation in place of jet fuel.

Table B40: Off-road transportation co-pollutant reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NOx	1,891
SO2	1,232
PM	191
CO	388
VOC	47

The transportation sector delivers notable health benefits from emissions reductions, with cumulative mortality reductions valued at $157 million between 2025 and 2050. While mortality gains are modest compared to other sectors, transportation still achieves significant improvements in respiratory health, avoiding over 10,000 cases and reducing missed school and workdays by nearly 8,900. These consistent reductions across multiple health outcomes underscore the sector's critical role in advancing air quality and public health objectives.

Table B41: Total transportation sector COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$157,214,517	11
Hospital Visits	$106,545	30
Missed School/Work or Restricted Activity	$8,652,748	8,868
Cardiovascular Conditions	$258,390	4
Respiratory Conditions	$8,152,362	10,217

Waste

In the Waste sector, the modeled strategies lead to modest emission reductions. The relatively small change in emissions leads to moderate health benefits compared to other sectors, with mortality benefits totaling $2.70 million and negligible gains in hospital visits and missed activity days. While not a major driver of MSA-wide benefits, the sector may still offer localized improvements, especially for communities around landfills.

Table B42: Waste co-pollutant reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
NO_x	51
PM	22
CO	950
VOC	5.2

The waste sector provides modest health benefits compared to other sectors, with cumulative monetary gains of about $2.8 million. While there are no reductions in mortality, hospital visits or cardiovascular conditions, the sector achieves measurable gains in respiratory health, avoiding over 100 cases, and reduces missed school and workdays by 170. The results highlight that, although waste is not a major driver of health benefits from emissions reductions, the sector still contributes to improvements in air quality and public health.

Table B43: Waste COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$2,695,318	0
Hospital Visits	$2,286	0
Missed School/Work or Restricted Activity	$54,700	170
Cardiovascular Conditions	$9,216	0
Respiratory Conditions	$64,237	112

Electricity Demand Changes

Electricity demand increases from electrification activities in the building, transportation, and industrial sectors.

Table B44: Electricity co-pollutant emissions reductions

Pollutant	Cumulative Reductions (MT) (2025-2050)
CO	520
NH_3	40
NO_x	111
PM10	108
PM25	174
SO_2	30
VOC	40

Because the GHG modeling assumes a shift to a clean grid under both the BAU and CCAP implementation scenarios, electricity sector co-pollutant reductions are relatively minor and show a relatively small impact on public health outcomes.

Table B45: Electricity COBRA benefits

Health Impact	Cumulative Monetary Benefits (2025-2050)	Cumulative Incidence Reduction (2025-2050)
Mortality	$17,799,484	1
Hospital Visits	$12,354	3
Missed School/Work or Restricted Activity	$845,946	1,031
Cardiovascular Conditions	$34,416	0
Respiratory Conditions	$818,081	1,069

Appendix C. Workforce Assessment

Introduction

Hampton Roads' ability to successfully implement its Comprehensive Climate Action Plan (CCAP) depends upon having sufficient skilled workers across all related sectors. This workforce gap analysis examines the degree to which the region's current and projected labor supply can meet CCAP implementation needs, identifying both workforce shortages that require immediate attention and surpluses that present opportunities for strategic retraining and redeployment. Implementation of measures in this CCAP may generate increased levels of demand for workers, in addition to current forecasts.

This technical appendix presents the completed workforce analysis in three parts. The first highlights Key Findings of the gap analysis, including specific occupations with shortages and surpluses, and outlines actionable strategies for workforce development, upskilling opportunities, educational partnerships, and goal setting. The Technical Approach provides a detailed workforce gap analysis methodology, examines employment trends from 2015-2025 with projections to 2035, identifies certifications and credentials that employers require for priority occupations, catalogs education and training providers in the region, and presents comprehensive workforce solutions tailored to CCAP implementation. Labor Market Data Tables contain complete labor market statistics, certification requirements, and training program details for all 53 occupations analyzed, serving as a technical reference for stakeholders engaged in workforce planning and program development.

The Workforce Analysis focused on understanding:

- The types of occupations and skills required to implement CCAP mitigation measures across six economic sectors: energy, buildings, transportation, waste, industry, and agriculture/natural lands;
- The alignment between existing regional workforce capabilities and future skill requirements; and
- Strategies to build local capacity through education, training, and workforce development partnerships.

This assessment was designed to provide regional leaders, localities, workforce councils, educational institutions, and employers with actionable insights to support equitable economic growth while advancing climate goals.

Key Findings

A total of 53 occupation types, representing approximately 88,100 jobs or 9.9% of total jobs in Hampton Roads in 2025, were identified as relevant to implementation of the Hampton Roads CCAP. This includes but is not limited to jobs in the construction and skilled trades, transportation, energy production and distribution, and agricultural industries. Based on existing labor market conditions and using projected growth, separations, and hires data from Lightcast[1], a labor market analytics tool, worker shortages or surpluses were estimated for each of the 53 occupations. From a workforce perspective, Hampton Roads is well-

[1] Lightcast. https://lightcast.io/. Accessed October 17, 2025.

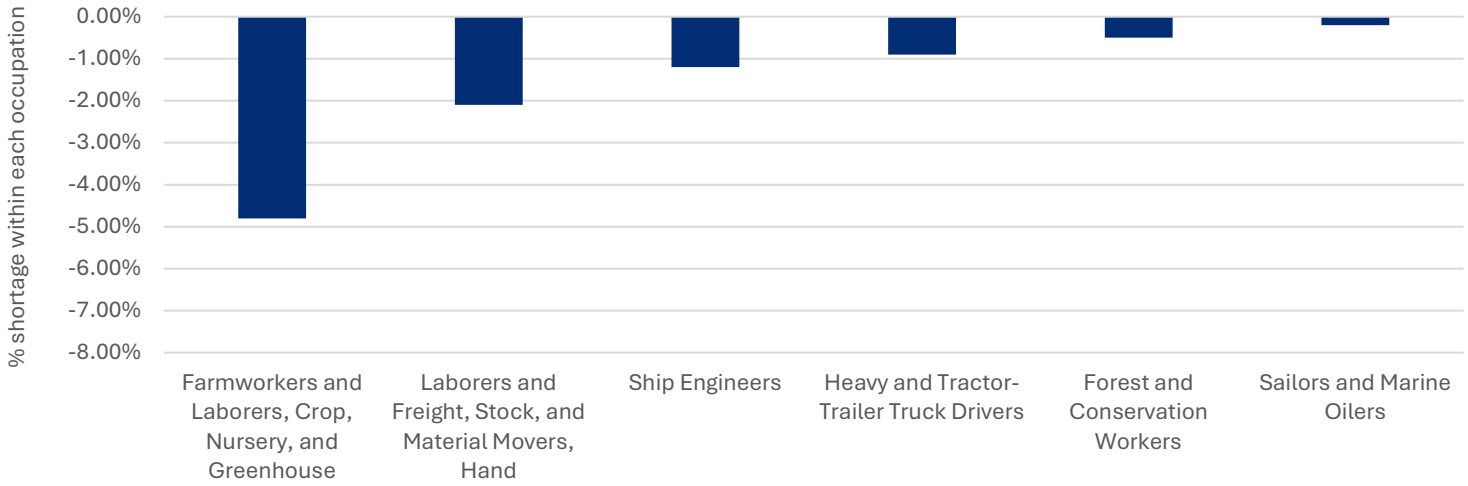
positioned to implement its CCAP. Overall, the region has enough workers in occupation types relevant to the CCAP measures, with only some relatively minor workforce shortages and growing surpluses projected over the next 10 years.

Workforce Shortages

Farmworkers, Laborers, Freight, Stock, and Material Movers – relevant to both the CCAP Ag and Natural Lands (NWL) and Offroad Transportation sectors – have the highest number of shortages, with an estimated current shortage of roughly 339 workers. Other Offroad Transportation sector shortages, all associated with Hampton Roads' numerous port activities and major regional economic driver, include Heavy and Tractor-Trailer Truck Drivers, Ship Engineers, and Sailors and Marine Oilers. Other occupations in the natural lands sector that are estimated to have shortages are Forest and Conservation Workers and Farmworkers and Laborers, Crop, Nursery, and Greenhouse.

Occupations identified with the largest shortages in 2025 (see Figure C1) are largely projected to continue to experience shortages over the next ten years, although to a lesser degree.

Figure C1: 2025 Largest Workforce Shortages



Workforce Surpluses

Hampton Roads has a higher level of worker surpluses in relevant occupations than shortages (see Figure C2). Light Truck Drivers demonstrate the greatest labor surplus, with a surplus of 357 workers, representing 7.0% of the total employed workforce as of 2025. Other sectors with worker surpluses are Transportation, Buildings, and Energy; with surpluses clustered in the construction sectors, including construction laborers and buildings trades occupations such as carpenters, electricians, and plumbers (see Table C1). Occupations that currently demonstrate the greatest surpluses are projected to experience increasing workforce surpluses in the future (see Table C2).

Figure C2: 2025 Largest Workforce Surpluses

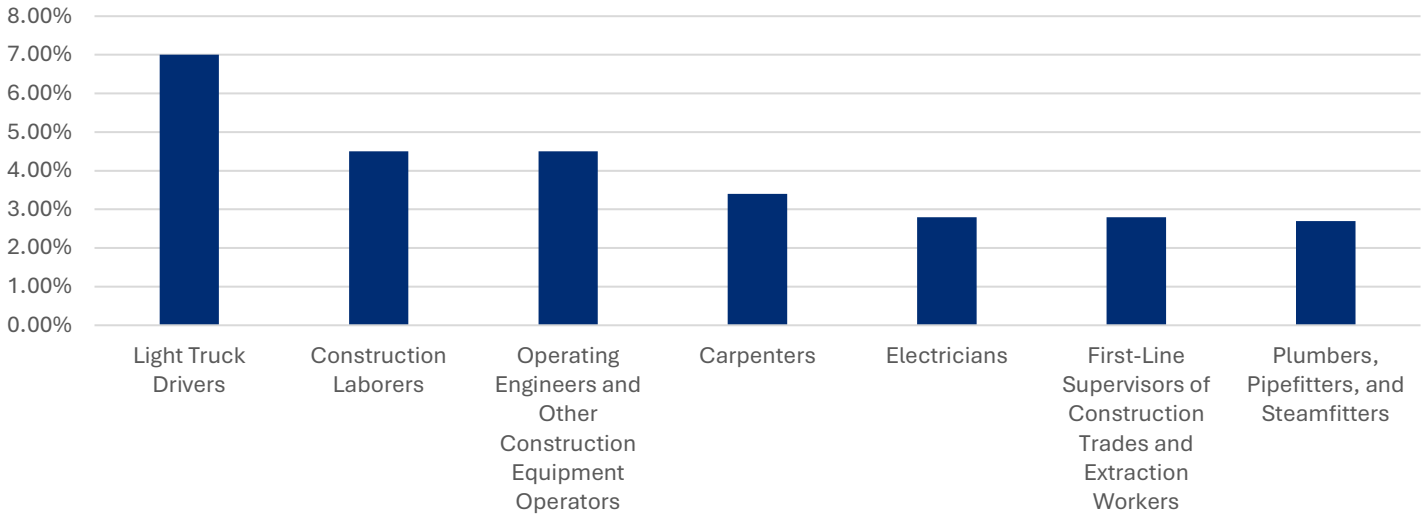


Table C1: Occupations with Largest Workforce Shortages 2025

SOC Code	Occupation	Relevant Sector	Shortage		
			Potential Workforce Shortage 2025	Potential Workforce Shortage 2035	Shortage as Percent of Total Employment 2025
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transportation	-339	-204	2.1%
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transportation	-66	49	0.9%
53-5031	Ship Engineers	Offroad Transportation	-18	-16	1.2%
45-4011	Forest and Conservation Workers	NWL	-14	-10	0.5%
53-5011	Sailors and Marine Oilers	Offroad Transportation	-12	-11	0.2%
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	-11	-6	4.8%

Table C2: Occupations with Largest Workforce Surplus 2025

SOC Code	Occupation	Relevant Sector	Surplus		
			Potential Workforce Surplus 2025	Potential Workforce Surplus 2035	Surplus as Percent of Total Employment 2025
53-3033	Light Truck Drivers	NWL	357	672	7.0%
47-2061	Construction Laborers	Buildings, Onroad Transportation	300	339	4.5%
47-2031	Carpenters	Buildings	172	158	3.4%
47-2111	Electricians	Energy, Buildings, Onroad Transportation	161	216	2.8%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transportation	157	178	2.8%
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transportation	110	123	4.5%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	104	126	2.7%

Addressing Workforce Shortages

While not quantified in this assessment, CCAP implementation will drive demand for greater activity across all sectors, with the largest potential growth in energy, buildings, and transportation – the same sectors responsible for most modeled greenhouse gas (GHG) reductions. As the pace of the energy transition increases, this added demand will exacerbate existing shortages and workforce challenges. While many of these occupations already exist within the region, increasing the scale and pace of climate-related investment will create new competition for workers. Without proactive training and recruitment strategies, the region could face delays in project implementation, higher labor costs, and reduced local benefit capture.

- Energy: Expansion of renewable generation, grid modernization, and distributed energy resources will drive new positions in electrical, mechanical, and construction trades.
- Buildings: Energy efficiency retrofits and electrification will create sustained demand for heating, ventilation, and air conditioning (HVAC) technicians, electricians, and energy auditors.
- Transportation: Electrification of vehicles and charging infrastructure deployment will increase need for electrical lineworkers, electric vehicle (EV) maintenance technicians, and manufacturing roles tied to battery systems. Transit expansion plans will require additional heavy duty vehicle drivers.
- Industry: Efficiency upgrades and process innovation will require engineers, maintenance staff, and technicians trained in new industrial control systems.
- Waste: Growth in organics diversion, methane recovery, and advanced treatment facilities will create opportunities in materials management and plant operations.
- Agriculture and Natural Lands: Habitat restoration, reforestation, and regenerative agricultural practices will expand employment in land management, equipment operation, and environmental services.

Shortages can be driven by many factors, not just a lack of skills or availability of training. Even when workers have the necessary skills and experience, a range of structural and economic barriers can limit their ability to find and keep stable employment. For example, students that graduate from local programs and universities may not be able to afford to live and stay in the region. In addition, strict job requirements—such as rigid degree mandates or years of experience thresholds—can exclude qualified candidates and narrow opportunities for advancement. High housing costs can force workers to live far from job centers, increasing commute times and reducing work-life balance. Meanwhile, the rising costs of childcare and transportation can make full-time employment financially unsustainable, especially for parents and lower-wage workers. Together, these factors contribute to higher turnover, reduced labor force participation, and ongoing challenges in worker retention across multiple industries.

The most significant workforce gaps are expected in skilled trades and technical occupations that support clean energy and infrastructure deployment. These gaps are driven by three interrelated factors:

1. Aging Workforce: Many skilled trades are facing retirements faster than replacements are entering the field.
2. Training Capacity Constraints: Existing technical programs and apprenticeships are operating near capacity and may require expansion to meet future demand.
3. Awareness and Access Barriers: Young workers and underrepresented populations often lack exposure to clean energy and climate-resilience career pathways.

Bridging these gaps will require coordinated efforts among employers, training providers, and workforce councils to align programs with CCAP implementation timelines.

In addition, quality of life concerns for certain jobs can lead to challenges in hiring. In the transit space, HRT is working with a consistent shortage of 40-50 bus operators, which is limiting how quickly further expansions of the 757 Express can be implemented. HRT is currently assessing options to ensure the current system routes are sustainable while considering strategies to more effectively attract new hires. One of the primary challenges faced by bus operators is quality of life concerns, leading to a smaller pool of potential workers.

Addressing these and other workforce barriers requires a coordinated, multi-stakeholder approach recognizing the interconnected nature of economic, social, and policy challenges. Collaboration among employers, government agencies, educational institutions, and community organizations will be needed to build supportive ecosystems for workers. Employers can adapt by offering more flexible job requirements, remote or hybrid options, and family-friendly benefits, while public agencies can invest in affordable housing, childcare infrastructure, and transportation access. Educational institutions and workforce boards can align training programs with real-time industry needs, ensuring that skill-building efforts translate into viable employment pathways. Lasting progress depends on shared responsibility – no single employer or sector can address these barriers alone – but through coordinated investment and policy alignment, communities can create conditions where workers and businesses thrive together.

Several strategies were identified to mitigate workforce shortages and strengthen the local labor pipeline:

- Build a workforce pipeline that ensures a reliable supply of qualified workers to implement the CCAP measures.
  - This can be achieved by developing partnerships with educational institutions and training providers to foster dynamic training programs and offer flexible certification pathways.
  - Increase enrollment capacity and outreach through partnerships with trade associations and unions.
  - Engage major regional employers and utilities in workforce planning to ensure training programs align with projected demand. The Hampton Roads region features a rich landscape of education and training resources, including high schools, technical education programs, community colleges, apprenticeships, and private training providers. In emerging fields like energy auditing, rooftop solar, and EV maintenance; specialized training is currently more limited. Expanding these offerings and updating curricula with the latest technology is key to closing workforce gaps.

- Examine opportunities to upskill or reskill the existing workforce from occupations with surpluses to occupations with shortages.
  - Surplus labor provides an opportunity for the region to retrain and redeploy workers into emerging fields aligned with CCAP priorities. For example, Construction Laborers, where there is a surplus, can transition to Laborers and Freight, Stock, and Material Movers, where there is a shortage, and Light Truck Drivers can transition to Heavy Tractor-Trailer Drivers. These skill transfers can often be accomplished with minimal additional training.
  - The transition to low carbon technologies may not fundamentally alter the occupational structure of the regional economy but will shift skill requirements toward electrification, digital systems, and sustainable materials management. Many of these skills overlap with those needed in existing high-demand industries such as maritime operations, construction, and logistics, offering opportunities for redeployment and upskilling. Key cross-cutting skills include:
    - Electrical and mechanical systems installation and maintenance.
    - Project management, data analytics, and systems integration.
    - Environmental monitoring, permitting, and compliance.
    - Engineering design, modeling, and GIS analysis.
    - Equipment operation and field maintenance for renewable energy and restoration projects.
  - The region's existing technical training and apprenticeship programs provide a strong foundation for meeting these needs, but capacity expansion and curriculum alignment will be necessary to fully support the CCAP implementation timeline. Partnerships among workforce development boards, community colleges, and employers will be essential for equipping workers with evolving skill sets and credentials.
- Promote interagency and intergovernmental coordination.
  - Build partnerships with and engage relevant state and local agencies when preparing to implement the CCAP measures. Share progress updates and plan coordinated points for data exchange. This collaborative approach fosters the alignment of resources and objectives.

Future discussion will be needed across the region with employers in key occupations to better understand their specific challenges in hiring and retaining workers, what programs and solutions they already have in place to address barriers, and how they could be involved in more regional collaborative initiatives to support their needs. Although Hampton Roads' workforce shortages are relatively minor today in the assessed occupations, addressing these shortages will ensure successful implementation of the CCAP. While workforce shortages and barriers go beyond skills and training, those remain fundamental elements of workforce development and will be critical to ensuring the region is ready to meet the challenges of CCAP implementation.

Developing a locally trained, highly skilled clean energy workforce will strengthen Hampton Roads' competitiveness in emerging industries, reduce reliance on external contractors, and enhance regional economic self-sufficiency. By investing in workforce development today, the region can ensure that its climate and economic objectives advance together, creating high-quality jobs while achieving sustained emissions reductions and resilience outcomes.

Sector Summary

Energy Sector

The energy sector represents one of the most significant opportunities for job creation under the CCAP. Expansion of renewable energy generation, particularly offshore wind, solar, and energy storage, will require substantial workforce growth across construction, installation, operation, and maintenance. Hampton Roads' existing maritime and manufacturing capabilities create a strong foundation for offshore wind development. Skilled trades such as electricians, welders, heavy equipment operators, and marine technicians are directly transferable to offshore wind construction and maintenance. Similarly,

electricians and construction laborers will be in demand for large-scale and distributed solar installations, energy storage systems, and grid modernization projects. The sector also presents opportunities in professional and technical services, including engineering, logistics, environmental permitting, and project management. Training needs will center on high-voltage safety, wind turbine technology, battery systems, and power electronics. Partnerships with local technical colleges can support these skill pipelines.

Buildings Sector

Building decarbonization measures, such as energy efficiency retrofits, high-performance new construction, and electrification, will create sustained workforce demand across the region. Implementation will rely heavily on the construction and building trades, where Hampton Roads already has a strong labor base. Energy auditors, HVAC technicians, electricians, and building performance specialists will be critical for improving energy efficiency and installing heat pumps and smart controls. Construction supervisors, insulation installers, and glazing professionals will also play essential roles in achieving building performance targets.

The main workforce challenges for this sector are scaling training capacity, ensuring consistent credentialing, and providing small contractors with access to financial and technical assistance to participate in retrofit programs. Community colleges and workforce boards can help close these gaps through targeted training in building science, electrification, and weatherization. Programs such as *Virginia Energy Workforce Consortium*, *Virginia Community College System (VCCS),* and *Community Housing Partner's Training Center* energy technology curricula can help align instruction with CCAP needs.

Transportation Sector

Transportation electrification and system optimization are expected to drive major employment growth through 2050. Jobs will emerge in both public and private sectors, including vehicle manufacturing, maintenance, charging infrastructure deployment, and transit system expansion. Electricians, mechanics, and technicians will be needed to install and maintain electric vehicle charging infrastructure and service electric fleet vehicles. Construction workers and civil engineers will support transit and active transportation projects, while planners and data analysts will guide system design and multimodal integration. Retraining programs for automotive technicians to service EVs and hybrids will be particularly important, as will workforce development around battery safety, diagnostics, and recycling. Stakeholders like the Virginia Clean Cities coalition and regional workforce development centers can play a key role in facilitating this transition.

Industry Sector

Industrial decarbonization measures, including process optimization, electrification, and fuel substitution, will require engineers, process operators, and maintenance staff skilled in new control systems and equipment. Hampton Roads' manufacturing and port logistics workforce provides a strong baseline for adaptation to low carbon industrial practices. Many industrial facilities are already investing in automation and energy management systems, which align with CCAP implementation needs. Priority training areas include advanced manufacturing, industrial energy management, and hydrogen and renewable natural gas systems. Collaboration among industrial firms, trade schools, and technical universities will be essential for building a skilled pipeline of technicians and operators familiar with next-generation equipment.

Waste Sector

The waste sector will experience new workforce opportunities tied to organic waste diversion, landfill gas recovery, and wastewater treatment improvements. Many of these jobs will build on existing public works and utility skill sets, expanding roles in facility operation, materials management, and methane capture. Key occupations include environmental technicians, plant operators, mechanics, and heavy equipment operators. As organics diversion programs expand, demand will also grow for composting facility staff, logistics coordinators, and quality-control specialists. Technical training programs focused on anaerobic digestion, composting operations, and biogas utilization will help prepare workers for these roles. Partnerships with the Virginia Department of Environmental Quality and regional solid waste authorities can support training and certification development.

Agriculture and Natural Lands Sector

The Agriculture and Natural Lands sector will contribute to emissions reduction through soil management, habitat restoration, and tree planting initiatives that also support local economies and ecosystem resilience. Job growth will occur in land management, conservation planning, and equipment operation for reforestation and wetland restoration projects. Opportunities also exist in nursery operations, seed production, and monitoring and verification of carbon sequestration. Priority training needs include natural resource management, GIS and remote sensing, and habitat restoration practices. Collaboration with Virginia Cooperative Extension, USDA NRCS, and local conservation districts will help align training and employment programs with emerging restoration and conservation goals.

Technical Approach

This section outlines the methodology and results for each component of the workforce analysis. The methodology leveraged labor market data from Lightcast to project future workforce gaps and inform strategic planning. The following sections of this Appendix examine labor gaps, certifications, education and training providers, and workforce solutions in context of the CCAP measures.

Workforce Analysis Methodology

The first step in the workforce analysis was the identification of occupations that might be impacted by the implementation of the CCAP measures. Each CCAP mitigation measure was linked to relevant industry and occupational codes using the North American Industry Classification System (NAICS) and the Standard Occupational Classification (SOC) framework. This mapping identified the primary and secondary occupations associated with activities such as renewable energy deployment, building retrofits, vehicle electrification, and land restoration. For example, the measure “Expand Utility-Scale Renewables” was mapped to NAICS 221114 (Solar Electric Power Generation) and corresponding SOC codes for construction laborers, electricians, and power plant operators. Similar linkages were developed for all CCAP measures to create a comprehensive crosswalk between emissions reduction strategies and the occupational categories they influence. The impacted occupations are listed in Table C9 in the Labor Market Data Tables section of this appendix.

To quantify the employment baseline for the identified occupations, data from Lightcast (formerly EMSI), Bureau of Labor Statistics (BLS) Occupational Employment and Wage Statistics (OEWS), and Virginia Employment Commission (VEC) were used for the Hampton Roads Metropolitan Statistical Area. Data included historic and projected employment, employment concentration, wages, typical education and training requirements, turnover rates, the number of hires, and openings. Projected employment growth was then estimated by applying national or state-level clean energy job multipliers, derived from studies conducted by NREL, DOE, and BW Research Partnership Energy Employment Reports. These multipliers were adjusted to reflect local market conditions, existing industrial capacity, and regional specialization factors.

Workforce gaps were determined by comparing projected growth in employment, occupational separations (using the turnover rate), and new hires for each occupation. In the analysis, new hires represent supply, and new growth and separations represent estimated demand. The difference between workforce supply and demand represents the gap, which can either be negative (indicating a shortage) or positive (indicating a surplus).

The analysis next compared occupational skill requirements with available regional training programs, apprenticeships, and certification pathways. Results identified areas where current training supply was sufficient and where capacity or curriculum updates would be needed to meet CCAP workforce requirements. This evaluation considered both quantitative metrics (number of graduates, program enrollment, completion rates) and qualitative inputs (curriculum content and industry alignment). Regional training data were collected from the VCCS, Hampton Roads Workforce Council, and local apprenticeship programs registered through the Virginia Department of Labor and Industry. Additionally, information from Lightcasts’s real-time job posting analytics on the certifications that employers seek when hiring for a selected set of priority occupations relevant to the

CCAP measures was used. These include: 1) EV Maintenance; 2) Energy Auditor; 3) Construction Laborer; 4) Roof Top Solar Installers; 5) Heat Pump Installers; 6) HVAC; 7) Farmers; 8) Landscaping Workers; 9) Electricians; 10) Electrical Engineers; 11) Heavy Tractor-Trailer Drivers; and 12) Bus Drivers, Transit. Data from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics (NCES) was also used to identify education and training providers in the metropolitan statistical area (MSA) that have programs that led to credentials requested by the occupations.

Employment Trends

A total of 53 occupations could be impacted by the implementation of the CCAP measures, including construction and skilled trades, transportation, energy production and distribution, and agricultural jobs. In total, these occupations represent roughly 88,100 jobs, or 9.9% of 890,845 total jobs in Hampton Roads as of 2025.

Table C3 shows the identified occupations that have grown the most in employment over the past ten years. The two highest growth occupations by number of positions added are Laborers and Freight, Stock, and Material Movers; and Heavy and Tractor-Trailer Drivers, adding 2,223 and 1,443 jobs, representing a 22.4% and a 19.3% increase, respectively. Workers in these occupations are employed in large numbers in Hampton Roads, much of which is associated with the Port of Virgina with facilities in Norfolk, Portsmouth, and Newport News.

Other construction and building trade occupations also grew considerably in the region in the past ten years, including First-Line Supervisors of Construction Trades; HVAC workers; Construction Laborers; Electricians; and Construction and Building inspectors. For a full breakdown of employment trends across all 53 CCAP-related occupations, refer to Table C10 the Labor Market Data Tables section of this appendix.

Table C3: CCAP Occupations with the Greatest Job Growth – 2015-2025

SOC	Occupation	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transportation	9,919	12,142	2,223	22.4%
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transportation	7,458	8,901	1,443	19.3%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Commercial Buildings, New Buildings, Residential Buildings, Onroad Transportation	4,596	5,559	964	21.0%
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transportation	2,136	2,951	815	38.2%
53-3033	Light Truck Drivers	NWL	4,301	5,103	802	18.6%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Commercial Buildings, Municipal, New Buildings, Residential Buildings	2,734	3,371	637	23.3%
47-2061	Construction Laborers	Commercial Buildings, New Buildings, Residential Buildings, Onroad Transportation	6,175	6,723	547	8.9%

SOC	Occupation	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
47-2111	Electricians	Commercial Buildings, Buildings and Energy Supply, Municipal, New Buildings, Residential Buildings, Onroad Transportation	5,525	5,832	307	5.6%
47-4011	Construction and Building Inspectors	Commercial Buildings, Buildings and Energy Supply, Municipal, New Buildings, Residential Buildings	831	994	162	19.5%
49-9051	Electrical Power-Line Installers and Repairers	Energy Supply	401	548	146	36.5%

Table C4 provides an overview of CCAP occupations in Hampton Roads that have undergone the most significant reductions in employment between 2015 and 2025. Nuclear Engineers and Ship Engineers have experienced the largest declines in employment over the past decade, losing 673 positions and 533 positions, respectively.

Table C4: CCAP Occupations with the Greatest Loss in Jobs Hampton Roads 2015-2025

SOC	Occupation	Relevant Sectors	2015 Jobs	2025 Jobs	Change	Percent Change
17-2161	Nuclear Engineers	Energy Supply	1,524	851	-673	-44.2%
53-5031	Ship Engineers	Offroad Transportation	1,725	1,192	-533	-30.9%
47-3012	Helpers--Carpenters	New Buildings, Residential Buildings	537	171	-367	-68.2%
53-7081	Refuse and Recyclable Material Collectors	Waste	785	454	-331	-42.2%
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transportation	2,184	1,900	-284	-13.0%
53-7021	Crane and Tower Operators	Offroad Transportation	755	478	-277	-36.7%
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	782	511	-271	-34.6%
53-3052	Bus Drivers, Transit and Intercity	Onroad Transportation	937	668	-269	-28.7%
53-5011	Sailors and Marine Oilers	Offroad Transportation	2,571	2,368	-203	-7.9%
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transportation	3,986	3,814	-172	-4.3%

Employment is projected to grow at a slower rate over the next ten years when compared to the previous ten years. Table C5 provides an overview of the occupations in Hampton Roads that are expected to experience the greatest projected growth in employment between 2025 and 2035. These are business as usual projections and do not consider the impact of CCAP

implementation. Light and Heavy Truck Drivers are projected to add the most workers, 854 and 130, respectively. However, this is a lower projected growth rate for Heavy and Tractor-Trailer Drivers than was observed over the past ten years. Between 2015 and 2025, jobs for Light and Heavy Truck Drivers grew by 18.6% and 19.3%, respectively, whereas these occupations are projected to grow by 16.7% and 1.5% over the next ten years. Relatedly, after strong job growth over the past ten years of Laborers and Freight, Stock, and Material Movers, the occupation is projected to remain relatively stagnant over the next ten years.

Table C5: CCAP Occupations with the Greatest Projected Job Growth – 2025-2035

SOC	Occupation	Relevant Sectors	2025 Jobs	Projected 2035 Jobs	Change	Percent Change
53-3033	Light Truck Drivers	NWL	5,103	5,957	854	16.7%
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transportation	8,901	9,031	130	1.5%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transportation	766	854	87	11.4%
53-3052	Bus Drivers, Transit and Intercity	Onroad Transportation	668	700	32	4.7%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transportation	12,142	12,173	31	0.3%
53-7081	Refuse and Recyclable Material Collectors	Waste	454	464	10	2.1%
45-2091	Agricultural Equipment Operators	NWL	149	155	7	4.5%
51-9011	Chemical Equipment Operators and Tenders	Industry	152	158	5	3.6%
47-2231	Solar Photovoltaic Installers	Buildings, Energy	29	34	5	16.1%
51-8011	Nuclear Power Reactor Operators	Energy Supply	37	41	4	11.1%

Table C6 highlights the occupations with the greatest projected decline in jobs between 2025 and 2035. Of the top ten declining occupations, six are in construction or related industries, including Carpenters; Supervisors of Construction Trades; Construction Laborers; Plumbers; HVAC workers; and Construction and Building Inspectors. This could be a result of a projected decline in building construction activity in the region over the next ten years. These are business as usual projections and do not consider the impact of CCAP implementation.

Table C6: CCAP Occupations with the Greatest Projected Decline in Jobs – 2025-2035

SOC	Occupation	Relevant Sectors	2025 Jobs	Projected 2035 Jobs	Change	Percent Change
47-2031	Carpenters	Buildings	5,062	4,576	-485	-9.6%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transportation	5,559	5,213	-347	-6.2%

SOC	Occupation	Relevant Sectors	2025 Jobs	Projected 2035 Jobs	Change	Percent Change
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transportation	3,814	3,558	-255	-6.7%
37-3011	Landscaping and Groundskeeping Workers	NWL	5,933	5,711	-222	-3.7%
47-2061	Construction Laborers	Buildings, Onroad Transportation	6,723	6,501	-222	-3.3%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	3,870	3,660	-210	-5.4%
53-5011	Sailors and Marine Oilers	Offroad Transportation	2,368	2,163	-205	-8.7%
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transportation	1,900	1,745	-155	-8.2%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	3,371	3,259	-112	-3.3%
47-4011	Construction and Building Inspectors	Buildings	994	885	-109	-11.0%

Gap Analysis

This gap analysis evaluates the difference between workforce supply and employer demand. As outlined in the methodology, demand is driven by both projected job growth and the need to replace workers who retire or change occupations. The supply is the actual number of hires. The gap analysis only considers current conditions and does not take into account the increased demand for these jobs that may result from implementing the CCAP measures.

Table C7 shows the occupations that are estimated to have the greatest workforce shortages in 2025. The region's workforce is well equipped to implement the CCAP measures with only a few minor shortages.

Table C7: CCAP Occupations with the Largest Projected Workforce Shortages in 2025

			Projected Supply	Projected Demand Subtotals		Projected Shortage	
Occupation	Relevant Sector	Jobs	Hires	Growth (New Jobs)	Projected Separations	Number of Jobs	% of Occupational Employment
Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transportation	12,142	13,105	84	13,360	-339	2.8%
Heavy and Tractor-Trailer Truck Drivers	Offroad Transportation	8,901	5,782	87	5,761	-66	0.7%
Ship Engineers	Offroad Transportation	1,192	762	(11)	791	-18	1.5%

			Projected Supply	Projected Demand Subtotals		Projected Shortage	
Occupation	Relevant Sector	Jobs	Hires	Growth (New Jobs)	Projected Separations	Number of Jobs	% of Occupational Employment
Sailors and Marine Oilers	Offroad Transportation	2,368	1,387	(21)	1,420	-12	0.5%
Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	511	818	2	827	-11	2.2%
Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transportation	766	381	24	367	-10	1.3%
Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	299	331	(2)	337	-4	1.4%
Agricultural Workers, All Other	NWL	117	166	(0)	170	-4	3.3%
Solar Photovoltaic Installers	Buildings, Energy	29	21	1	23	-3	9.5%

Table C8 shows the CCAP occupations that are estimated to have the greatest surpluses in workers in 2025 in Hampton Roads. These occupations include several in the construction sector, which is projected to decline over the next ten years, potentially increasing the surplus. The occupations with significant surpluses include Construction Laborers, Carpenters, Electricians and Electricians Helpers, Supervisors of Construction Trades, Operating Engineers, Plumbers, and HVAC workers. These occupations are important for the buildings sector, and implementing CCAP measures in this sector could leverage these surpluses.

Assessing labor surpluses provides insight into where there could be opportunities for workers to transition their skills from one occupation to another occupation that may be in greater demand. For example, Landscaping Workers, where there is a surplus, can transition to Laborers and Freight, Stock, and Material Movers, where there is a shortage, or Light Truck Drivers can transition to Heavy and Tractor-Trailer Drivers. These skill transfers can often be successful with minimal additional training.

Table C8: CCAP Occupations with the Largest Estimated Workforce Surpluses in 2025

			Projected Supply	Projected Demand Subtotals		2025 Projected Surplus	
Occupation	Relevant Sector	Jobs	Hires	Growth (New Jobs)	Projected Separations	Number of Jobs	% of Occupational Employment
Light Truck Drivers	NWL	5,103	5,429	214	4,859	357	7.0%
Construction Laborers	Buildings, Onroad Transportation	6,723	4,763	7	4,456	300	4.5%
Carpenters	Buildings	5,062	2,490	(54)	2,373	172	3.4%
Electricians	Buildings, Energy Onroad Transportation	5,832	2,544	31	2,352	161	2.8%
First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transportation	5,559	2,104	(13)	1,960	157	2.8%
Operating Engineers and Other Construction Equipment Operators	Onroad Transportation	2,457	1,338	2	1,226	110	4.5%
Plumbers, Pipefitters, and Steamfitters	Buildings	3,870	1,820	(1)	1,717	104	2.7%
Helpers--Electricians	Buildings, Energy Onroad Transportation	678	1,184	(2)	1,103	83	12.3%
Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	3,371	1,704	7	1,624	72	2.1%
Landscaping and Groundskeeping Workers	NWL	5,933	4,256	(0)	4,206	49	0.8%

Certifications

A comprehensive evaluation of the most sought-after skills and certifications for key CCAP occupations was conducted. This review focused on roles such as EV maintenance technicians, energy auditors, construction laborers, rooftop solar installers, heat pump installers, HVAC specialists, farmers, landscaping workers, electricians, electrical engineers, heavy tractor-trailer drivers, and transit bus drivers. Real-time job posting data from Lightcast provided insight into employer requirements for these positions.

Findings revealed that, for many CCAP-related jobs, employers are consistently seeking candidates with specific certifications and skills. This trend is especially notable for electric vehicle mechanics, energy auditing, rooftop solar installation, and building trades such as electricians, HVAC technicians, and heat pump installers. Key certifications include the Electric Vehicle Fundamentals (EVF) Certification for EV mechanics, the Certified Energy Auditor (CEA) for energy auditors, the photovoltaic (PV) Installation Professional (PVIP) Certification for solar installers, the Environmental Protection Agency (EPA) Section 608 Technician Certification for HVAC and heat pump specialists, and the Journeyman Electrician License for electricians.

On the other hand, employers hiring for occupations such as construction laborers, landscapers, and agricultural workers typically do not require formal certifications. For a detailed breakdown of the top certifications required for each key CCAP occupation, see Tables C15-C26 in the Labor Market Data Tables section of this appendix.

Certifications and skills are critical for many occupations, but for some other barriers and quality of life concerns may lead to challenges in hiring new workers. Even when workers have the necessary skills and experience, a range of structural and economic barriers can limit their ability to find and keep stable employment. See the Addressing Workforce Shortages section above for more details.

Education and Training Providers

Education and training providers across Hampton Roads are key resources for supplying the credentials and certifications sought by employers for occupations relevant to CCAP measure implementation. Training providers can play a pivotal role in bridging workforce gaps by updating curricula, incorporating the latest technologies, and expanding programs to align with industry and CCAP implementation demands.

While the region boasts a strong array of training programs for traditional building trades, there are notably fewer options in newer fields like energy auditing, rooftop solar installation, and EV maintenance. For building trades, agricultural trades, and transit-related positions, a variety of pathways are available, including high school and technical education, community colleges, apprenticeship programs, and private training providers. However, specialized training in energy auditing, rooftop solar, and EV maintenance is more limited. See Tables C27-C37 in the Labor Market Data Tables section of this appendix, for a comprehensive list of educational and training providers relevant to each major CCAP occupation.

Workforce Solutions

This gap analysis is meant to inform workforce development strategies, ensuring they focus on areas with the greatest need. Effective management of workforce imbalances involves proactive measures, such as targeted recruitment, training, and education initiatives tailored to CCAP needs. Partnerships between government, industry, and educational institutions can help align labor supply with emerging demands, ensuring that the region is equipped to meet CCAP goals. Ultimately, understanding and addressing workforce shortages and surpluses is crucial for successful CCAP implementation. See Table C14 in the Labor Market Data Tables section of this appendix for the gap analysis for all CCAP occupations.

Addressing the workforce challenges associated with CCAP implementation will involve four key components: 1) leveraging opportunities for upskilling and reskilling workers; 2) expanding ongoing and investing in new education opportunities 3) developing partnerships; and 4) setting, tracking, and continually refining goals.

Leveraging Opportunities for Upskilling and Reskilling Workers

The labor market and workforce gap analysis identified some of the current needs that should be addressed to successfully implement the CCAP. These include workforce shortages among Laborers; Heavy Tractor-Trailer Drivers; and Freight, Stock, and Material Movers. Shortages in these areas present opportunities for upskilling and reskilling workers to meet demand, especially by training current Light Truck Drivers, Construction Laborers, Helpers-Electricians, and Landscaping Workers to take on similar work in different occupations.

Expanding Ongoing and Investing in New Education Opportunities

There exists a lack of training opportunities for key skills and a lack of pathways towards obtaining key credentials, including:

- EVF Certification for EV mechanics
- CEA for energy auditors
- PVIP Certification for solar installers
- EPA Section 608 Technician Certification for HVAC and heat pump specialists
- Journeyman Electrician License for electricians

Expanding ongoing education and training opportunities, as well as investing in new pathways will ensure that Hampton Roads has the workforce it needs to successfully implement the CCAP measures. The region features a rich landscape of education and training resources, particularly for traditional building trades. Pathways include high school and technical education programs, community colleges, apprenticeships, and private institutions. However, in emerging fields like energy auditing, rooftop solar, and EV maintenance, specialized training is more limited. Expanding these offerings and updating curricula with the latest technology is key to closing workforce gaps.

Developing Partnerships

When developing solutions to address workforce shortage challenges, building new partnerships for effective implementation is critical. Effective workforce development requires collaboration among a diverse array of stakeholders, particularly in education and training, to provide access to trainings for upskilling and reskilling. Forming partnerships with colleges and training providers offering programs in key CCAP-related occupations can help meet the emerging needs.

Other stakeholders involved in the process of upskilling and reskilling the workforce include employers, workforce development boards, and other state or local workforce organizations, as well as local labor organizations. Building new partnerships and strengthening existing ones are crucial for successful CCAP implementation.

Setting, Tracking, and Continually Refining Goals

Setting, tracking, and continually refining goals throughout implementation will be important to measure Hampton Roads' success in addressing the projected workforce shortages in implementing the CCAP measures. Metrics could include:

- Number of jobs created in a given occupation
- Number of workers trained in a given program
- Training programs developed in a given sector

By tracking these benchmarks and visualizing benchmarking data through digital dashboards, Hampton Roads can measure progress and maintain alignment with CCAP priorities throughout the process.

Labor Market Data Tables

Labor Market Review

Table C9: Occupations Impacted by CCAP Measures

SOC	Occupation	Relevant Sectors
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL
17-2161	Nuclear Engineers	Energy
19-1013	Soil and Plant Scientists	NWL
19-1032	Foresters	NWL
19-4071	Forest and Conservation Technicians	NWL
37-3011	Landscaping and Groundskeeping Workers	NWL
37-3013	Tree Trimmers and Pruners	NWL
45-2091	Agricultural Equipment Operators	NWL
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL
45-2099	Agricultural Workers, All Other	NWL
45-4011	Forest and Conservation Workers	NWL
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport
47-2031	Carpenters	Buildings
47-2061	Construction Laborers	Buildings, Onroad Transport
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport
47-2111	Electricians	Buildings, Energy, Onroad Transport
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings
47-2231	Solar Photovoltaic Installers	Buildings, Energy
47-3012	Helpers--Carpenters	Buildings
47-3013	Helpers--Electricians	Buildings, Energy Onroad Transport
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings
47-4011	Construction and Building Inspectors	Buildings, Energy
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy

SOC	Occupation	Relevant Sectors
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings
49-9031	Home Appliance Repairers	Buildings
49-9051	Electrical Power-Line Installers and Repairers	Energy
49-9081	Wind Turbine Service Technicians	Buildings, Energy
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport
51-8011	Nuclear Power Reactor Operators	Energy
51-8012	Power Distributors and Dispatchers	Energy
51-8013	Power Plant Operators	Energy
51-8021	Stationary Engineers and Boiler Operators	Energy
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater
51-8091	Chemical Plant and System Operators	Industry
51-9011	Chemical Equipment Operators and Tenders	Industry
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport
53-3033	Light Truck Drivers	NWL
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport
53-5011	Sailors and Marine Oilers	Offroad Transport
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport
53-5031	Ship Engineers	Offroad Transport
53-7021	Crane and Tower Operators	Offroad Transport
53-7041	Hoist and Winch Operators	Offroad Transport
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport
53-7081	Refuse and Recyclable Material Collectors	Waste
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport

Table C10: Employment Trends and Projections 2015-2035

SOC	Occupation	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL	755	678	626	621	616
17-2161	Nuclear Engineers	Energy	1,524	1,163	851	839	825
19-1013	Soil and Plant Scientists	NWL	59	41	59	60	61
19-1032	Foresters	NWL	71	139	212	209	205
19-4071	Forest and Conservation Technicians	NWL	130	159	213	213	209
37-3011	Landscaping and Groundskeeping Workers	NWL	5,867	5,671	5,933	5,847	5,711
37-3013	Tree Trimmers and Pruners	NWL	367	457	320	314	305
45-2091	Agricultural Equipment Operators	NWL	136	138	149	154	155
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	782	547	511	514	512
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	327	276	299	294	289
45-2099	Agricultural Workers, All Other	NWL	115	116	117	117	116
45-4011	Forest and Conservation Workers	NWL	45	62	39	38	38
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport	4,596	4,706	5,559	5,405	5,213
47-2031	Carpenters	Buildings	5,233	5,168	5,062	4,813	4,576
47-2061	Construction Laborers	Buildings, Onroad Transport	6,175	6,200	6,723	6,644	6,501
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport	418	386	262	258	252
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport	2,345	2,131	2,457	2,416	2,354
47-2111	Electricians	Buildings, Energy, Onroad Transport	5,525	5,700	5,832	5,832	5,740
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings	99	61	59	57	54
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	5,129	4,705	3,870	3,785	3,660
47-2231	Solar Photovoltaic Installers	Buildings, Energy	96	12	29	33	34

SOC	Occupation	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
47-3012	Helpers--Carpenters	Buildings	537	361	171	159	149
47-3013	Helpers--Electricians	Buildings, Energy, Onroad Transport	618	670	678	657	631
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings	481	464	382	375	361
47-4011	Construction and Building Inspectors	Buildings, Energy	831	1,010	994	933	885
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy	378	367	199	189	182
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy	239	210	283	265	252
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport	73	116	208	181	164
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	2,734	3,093	3,371	3,337	3,259
49-9031	Home Appliance Repairers	Buildings	266	295	329	315	305
49-9051	Electrical Power-Line Installers and Repairers	Energy	401	426	548	554	547
49-9081	Wind Turbine Service Technicians	Buildings, Energy	5	5	14	13	15
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport	659	697	766	826	854
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport	3,986	3,613	3,814	3,714	3,558
51-8011	Nuclear Power Reactor Operators	Energy	67	65	37	40	41
51-8012	Power Distributors and Dispatchers	Energy	51	49	65	63	62
51-8013	Power Plant Operators	Energy	83	93	103	99	96
51-8021	Stationary Engineers and Boiler Operators	Energy	336	155	167	166	162
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater	457	529	445	401	368
51-8091	Chemical Plant and System Operators	Industry	22	18	5	5	5

SOC	Occupation	Relevant Sectors	2015 Jobs	2020 Jobs	2025 Jobs	2030 Jobs	2035 Jobs
51-9011	Chemical Equipment Operators and Tenders	Industry	81	68	152	158	158
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport	2,136	2,661	2,951	2,961	2,928
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport	7,458	8,388	8,901	9,044	9,031
53-3033	Light Truck Drivers	NWL	4,301	4,834	5,103	5,676	5,957
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport	937	728	668	697	700
53-5011	Sailors and Marine Oilers	Offroad Transport	2,571	2,399	2,368	2,260	2,163
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport	2,184	1,759	1,900	1,821	1,745
53-5031	Ship Engineers	Offroad Transport	1,725	1,403	1,192	1,135	1,084
53-7021	Crane and Tower Operators	Offroad Transport	755	766	478	469	453
53-7041	Hoist and Winch Operators	Offroad Transport	30	76	5	5	5
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport	9,919	11,117	12,142	12,245	12,173
53-7081	Refuse and Recyclable Material Collectors	Waste	785	504	454	464	464
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport	226	163	27	28	29

Table C11: Percent Change in Employment

SOC	Occupation	Relevant Sectors	Percent Change 2015-2020	Percent Change 2020-2025	Percent Change 2025-2030	Percent Change 2030-2035
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL	-10.2%	-7.7%	-0.8%	-0.7%
17-2161	Nuclear Engineers	Energy	-23.7%	-26.9%	-1.4%	-1.7%
19-1013	Soil and Plant Scientists	NWL	-31.1%	43.4%	2.8%	0.8%
19-1032	Foresters	NWL	97.1%	52.3%	-1.6%	-1.8%
19-4071	Forest and Conservation Technicians	NWL	21.7%	34.2%	0.1%	-1.9%
37-3011	Landscaping and Groundskeeping Workers	NWL	-3.3%	4.6%	-1.5%	-2.3%
37-3013	Tree Trimmers and Pruners	NWL	24.4%	-29.9%	-2.0%	-3.0%

SOC	Occupation	Relevant Sectors	Percent Change 2015-2020	Percent Change 2020-2025	Percent Change 2025-2030	Percent Change 2030-2035
45-2091	Agricultural Equipment Operators	NWL	1.2%	7.9%	3.3%	1.2%
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	-30.0%	-6.6%	0.6%	-0.5%
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	-15.6%	8.3%	-1.5%	-1.7%
45-2099	Agricultural Workers, All Other	NWL	1.0%	1.0%	-0.5%	-0.7%
45-4011	Forest and Conservation Workers	NWL	37.9%	-36.4%	-2.0%	-1.8%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport	2.4%	18.1%	-2.8%	-3.5%
47-2031	Carpenters	Buildings	-1.2%	-2.1%	-4.9%	-4.9%
47-2061	Construction Laborers	Buildings, Onroad Transport	0.4%	8.4%	-1.2%	-2.2%
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport	-7.6%	-32.3%	-1.5%	-2.2%
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport	-9.2%	15.3%	-1.7%	-2.6%
47-2111	Electricians	Buildings, Energy, Onroad Transport	3.2%	2.3%	0.0%	-1.6%
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings	-38.1%	-4.1%	-3.6%	-5.0%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	-0.3%	5.9%	0.4%	0.4%
47-2231	Solar Photovoltaic Installers	Buildings	-87.2%	139.0%	13.0%	2.7%
47-3012	Helpers--Carpenters	Buildings	-32.9%	-52.7%	-6.6%	-6.7%
47-3013	Helpers--Electricians	Buildings, Energy, Onroad Transport	8.4%	1.2%	-3.1%	-4.0%
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings	-3.6%	-17.7%	-1.9%	-3.7%
47-4011	Construction and Building Inspectors	Buildings, Energy	21.5%	-1.6%	-6.1%	-5.2%
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy	-3.1%	-45.8%	-4.9%	-3.5%

SOC	Occupation	Relevant Sectors	Percent Change 2015-2020	Percent Change 2020-2025	Percent Change 2025-2030	Percent Change 2030-2035
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy	-12.4%	35.1%	-6.3%	-4.9%
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport	58.5%	78.9%	-12.9%	-9.5%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	13.1%	9.0%	-1.0%	-2.3%
49-9031	Home Appliance Repairers	Buildings	10.8%	11.6%	-4.2%	-3.5%
49-9051	Electrical Power-Line Installers and Repairers	Energy	6.3%	28.4%	1.1%	-1.2%
49-9081	Wind Turbine Service Technicians	Buildings, Energy	0.0%	170.1%	-1.7%	14.1%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport	5.7%	10.0%	7.8%	3.3%
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport	-9.3%	5.5%	-2.6%	-4.2%
51-8011	Nuclear Power Reactor Operators	Energy	-2.6%	-43.2%	7.2%	3.6%
51-8012	Power Distributors and Dispatchers	Energy	-4.1%	32.4%	-2.1%	-2.8%
51-8013	Power Plant Operators	Energy	12.9%	10.2%	-3.8%	-3.1%
51-8021	Stationary Engineers and Boiler Operators	Energy	-53.9%	7.7%	-0.8%	-2.4%
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater	15.8%	-15.8%	-10.0%	-8.1%
51-8091	Chemical Plant and System Operators	Industry	-19.6%	-71.7%	0.0%	0.0%
51-9011	Chemical Equipment Operators and Tenders	Industry	-16.0%	124.1%	4.0%	-0.4%
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport	24.6%	10.9%	0.3%	-1.1%
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport	12.5%	6.1%	1.6%	-0.1%
53-3033	Light Truck Drivers	NWL	12.4%	5.6%	11.2%	5.0%
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport	-22.3%	-8.3%	4.3%	0.4%

SOC	Occupation	Relevant Sectors	Percent Change 2015-2020	Percent Change 2020-2025	Percent Change 2025-2030	Percent Change 2030-2035
53-5011	Sailors and Marine Oilers	Offroad Transport	-6.7%	-1.3%	-4.6%	-4.3%
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport	-19.4%	8.0%	-4.1%	-4.2%
53-5031	Ship Engineers	Offroad Transport	-18.7%	-15.0%	-4.8%	-4.5%
53-7021	Crane and Tower Operators	Offroad Transport	1.4%	-37.5%	-1.9%	-3.5%
53-7041	Hoist and Winch Operators	Offroad Transport	157.9%	-93.4%	0.0%	0.0%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport	12.1%	9.2%	0.8%	-0.6%
53-7081	Refuse and Recyclable Material Collectors	Waste	-35.8%	-10.0%	2.1%	0.0%
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport	-27.9%	-83.6%	4.2%	3.7%

Table C12: Employment Concentrations – Location Quotient (LQ) 2025

SOC	Occupation	Relevant Sectors	LQ
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL	0.21
17-2161	Nuclear Engineers	Energy	10.77
19-1013	Soil and Plant Scientists	NWL	0.53
19-1032	Foresters	NWL	3.25
19-4071	Forest and Conservation Technicians	NWL	1.16
37-3011	Landscaping and Groundskeeping Workers	NWL	0.91
37-3013	Tree Trimmers and Pruners	NWL	0.91
45-2091	Agricultural Equipment Operators	NWL	0.38
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	0.17
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	0.33
45-2099	Agricultural Workers, All Other	NWL	0.25
45-4011	Forest and Conservation Workers	NWL	0.35
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport	1.23
47-2031	Carpenters	Buildings	0.96
47-2061	Construction Laborers	Buildings, Onroad Transport	0.91
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport	1.05

SOC	Occupation	Relevant Sectors	LQ
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport	0.98
47-2111	Electricians	Buildings, Energy, Onroad Transport	1.37
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings	0.29
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	1.46
47-2231	Solar Photovoltaic Installers	Buildings, Energy	0.20
47-3012	Helpers--Carpenters	Buildings	1.45
47-3013	Helpers--Electricians	Buildings, Energy, Onroad Transport	1.81
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings	1.54
47-4011	Construction and Building Inspectors	Buildings, Energy	1.32
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy	3.65
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy	1.88
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport	4.43
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	1.43
49-9031	Home Appliance Repairers	Buildings	1.56
49-9051	Electrical Power-Line Installers and Repairers	Energy	0.83
49-9081	Wind Turbine Service Technicians	Buildings, Energy	0.20
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport	0.53
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport	0.50
51-8011	Nuclear Power Reactor Operators	Energy	1.15
51-8012	Power Distributors and Dispatchers	Energy	1.17
51-8013	Power Plant Operators	Energy	0.59
51-8021	Stationary Engineers and Boiler Operators	Energy	0.80
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater	0.73
51-8091	Chemical Plant and System Operators	Industry	0.00
51-9011	Chemical Equipment Operators and Tenders	Industry	0.24
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport	0.94
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport	0.73

SOC	Occupation	Relevant Sectors	LQ
53-3033	Light Truck Drivers	NWL	0.88
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport	0.62
53-5011	Sailors and Marine Oilers	Offroad Transport	10.30
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport	7.39
53-5031	Ship Engineers	Offroad Transport	16.16
53-7021	Crane and Tower Operators	Offroad Transport	2.03
53-7041	Hoist and Winch Operators	Offroad Transport	0.46
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport	0.77
53-7081	Refuse and Recyclable Material Collectors	Waste	0.58
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport	0.37

Table C13: Wages 2025

SOC	Occupation	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL	$4,818	$16,103	$29,714	$58,172	$126,226
17-2161	Nuclear Engineers	Energy	$83,003	$90,131	$102,413	$119,537	$140,702
19-1013	Soil and Plant Scientists	NWL	$36,425	$44,226	$60,437	$80,949	$103,261
19-1032	Foresters	NWL	$57,494	$68,768	$82,749	$95,013	$112,628
19-4071	Forest and Conservation Technicians	NWL	$44,594	$50,292	$60,601	$70,314	$82,900
37-3011	Landscaping and Groundskeeping Workers	NWL	$24,943	$29,071	$34,416	$41,004	$48,555
37-3013	Tree Trimmers and Pruners	NWL	$29,490	$35,984	$40,599	$55,022	$66,945
45-2091	Agricultural Equipment Operators	NWL	$24,961	$26,768	$36,685	$45,485	$53,237
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	$24,961	$25,040	$28,255	$36,713	$47,259
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	$24,960	$25,079	$29,022	$40,389	$56,418
45-2099	Agricultural Workers, All Other	NWL	$24,961	$25,966	$34,485	$46,901	$62,470

SOC	Occupation	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
45-4011	Forest and Conservation Workers	NWL	$19,374	$26,188	$32,501	$42,972	$57,912
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport	$47,000	$57,285	$69,540	$81,103	$101,185
47-2031	Carpenters	Buildings	$33,553	$38,519	$48,585	$58,598	$69,052
47-2061	Construction Laborers	Buildings, Onroad Transport	$27,786	$31,028	$37,091	$43,947	$50,694
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport	$33,606	$38,699	$46,211	$50,471	$63,858
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport	$36,727	$41,039	$47,123	$53,862	$61,749
47-2111	Electricians	Buildings, Energy, Onroad Transport	$36,947	$46,852	$58,682	$66,388	$78,095
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings	$26,271	$27,578	$32,565	$42,516	$51,796
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	$38,022	$46,338	$57,226	$64,343	$73,503
47-2231	Solar Photovoltaic Installers	Buildings	$39,089	$42,314	$44,653	$49,305	$53,465
47-3012	Helpers--Carpenters	Buildings	$30,518	$33,381	$38,425	$43,852	$49,090
47-3013	Helpers--Electricians	Buildings, Energy, Onroad Transport	$30,106	$33,159	$38,484	$46,130	$52,101
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings	$29,421	$31,600	$36,443	$41,434	$46,312
47-4011	Construction and Building Inspectors	Buildings, Energy	$44,787	$51,217	$62,396	$73,689	$89,888
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy	$57,149	$67,183	$78,447	$81,453	$84,521
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy	$51,384	$67,435	$91,452	$99,648	$105,822

SOC	Occupation	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport	$39,282	$42,377	$45,601	$54,884	$65,262
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	$37,339	$46,083	$54,692	$62,499	$75,098
49-9031	Home Appliance Repairers	Buildings	$30,516	$42,508	$49,846	$61,276	$70,250
49-9051	Electrical Power-Line Installers and Repairers	Energy	$39,992	$49,112	$60,999	$83,551	$101,129
49-9081	Wind Turbine Service Technicians	Buildings, Energy	$28,033	$41,238	$53,116	$68,995	$90,491
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport	$31,539	$34,685	$38,875	$46,304	$54,413
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport	$30,157	$33,881	$38,421	$46,655	$56,149
51-8011	Nuclear Power Reactor Operators	Energy	$84,493	$96,144	$107,447	$118,429	$138,717
51-8012	Power Distributors and Dispatchers	Energy	$56,331	$60,494	$67,737	$92,713	$110,480
51-8013	Power Plant Operators	Energy	$60,507	$67,754	$75,002	$79,301	$91,412
51-8021	Stationary Engineers and Boiler Operators	Energy	$43,316	$48,866	$58,110	$64,051	$70,418
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater	$34,704	$39,732	$49,133	$63,216	$70,059
51-8091	Chemical Plant and System Operators	Industry	Insf. Data	Insf. Data	Insf. Data	Insf. Data	Insf. Data
51-9011	Chemical Equipment Operators and Tenders	Industry	$39,430	$40,023	$42,956	$47,419	$63,730
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport	$38,442	$45,857	$58,969	$73,403	$91,395

SOC	Occupation	Relevant Sectors	Pct. 10 Annual Earnings	Pct. 25 Annual Earnings	Median Annual Earnings	Pct. 75 Annual Earnings	Pct. 90 Annual Earnings
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport	$33,964	$40,967	$47,281	$57,195	$68,178
53-3033	Light Truck Drivers	NWL	$25,139	$29,352	$37,115	$48,171	$69,990
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport	$35,426	$37,447	$42,462	$50,594	$60,188
53-5011	Sailors and Marine Oilers	Offroad Transport	$29,569	$38,168	$43,076	$52,119	$55,864
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport	$42,301	$59,621	$78,671	$94,657	$122,435
53-5031	Ship Engineers	Offroad Transport	$44,645	$54,092	$75,686	$115,901	$152,869
53-7021	Crane and Tower Operators	Offroad Transport	$58,984	$63,164	$64,603	$68,432	$75,022
53-7041	Hoist and Winch Operators	Offroad Transport	Insf. Data	Insf. Data	Insf. Data	Insf. Data	Insf. Data
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport	$29,956	$34,476	$39,497	$48,413	$61,428
53-7081	Refuse and Recyclable Material Collectors	Waste	$26,581	$30,424	$39,377	$51,667	$54,894
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport	$40,926	$43,430	$52,314	$64,744	$82,162

Table C14: Near-Term Gap Analysis Data

			2025 Supply	2025 Demand		Potential Shortage or Surplus		
SOC Code	Occupation	Relevant Sector	Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
11-9013	Farmers, Ranchers, and Other Agricultural Managers	NWL	172	(2)	175	-1	-1	0.2%
17-2161	Nuclear Engineers	Energy	265	0	245	20	23	2.4%
19-1013	Soil and Plant Scientists	NWL	27	1	25	1	2	2.1%
19-1032	Foresters	NWL	100	(0)	93	7	7	3.2%

SOC Code	Occupation	Relevant Sector	2025 Supply	2025 Demand		Potential Shortage or Surplus		
			Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
19-4071	Forest and Conservation Technicians	NWL	85	1	77	7	9	3.1%
37-3011	Landscaping and Groundskeeping Workers	NWL	4,256	(0)	4,206	49	78	0.8%
37-3013	Tree Trimmers and Pruners	NWL	273	(1)	274	0	1	0.0%
45-2091	Agricultural Equipment Operators	NWL	161	2	162	-2	-1	1.7%
45-2092	Farmworkers and Laborers, Crop, Nursery, and Greenhouse	NWL	818	2	827	-11	-6	2.2%
45-2093	Farmworkers, Farm, Ranch, and Aquacultural Animals	NWL	331	(2)	337	-4	-3	1.4%
45-2099	Agricultural Workers, All Other	NWL	166	(0)	170	-4	-3	3.3%
45-4011	Forest and Conservation Workers	NWL	158	(1)	173	-14	-10	36.6%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Buildings, Onroad Transport	2,104	(13)	1,960	157	178	2.8%
47-2031	Carpenters	Buildings	2,490	(54)	2,373	172	158	3.4%
47-2061	Construction Laborers	Buildings, Onroad Transport	4,763	7	4,456	300	339	4.5%

SOC Code	Occupation	Relevant Sector	2025 Supply	2025 Demand		Potential Shortage or Surplus		
			Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
47-2071	Paving, Surfacing, and Tamping Equipment Operators	Onroad Transport	157	2	140	15	18	5.9%
47-2073	Operating Engineers and Other Construction Equipment Operators	Onroad Transport	1,338	2	1,226	110	123	4.5%
47-2111	Electricians	Buildings, Energy, Onroad Transport	2,544	31	2,352	161	216	2.8%
47-2131	Insulation Workers, Floor, Ceiling, and Wall	Buildings	34	(2)	34	2	2	4.0%
47-2152	Plumbers, Pipefitters, and Steamfitters	Buildings	1,820	(1)	1,717	104	126	2.7%
47-2231	Solar Photovoltaic Installers	Buildings, Energy	21	1	23	-3	-3	9.5%
47-3012	Helpers--Carpenters	Buildings	347	(2)	341	8	6	4.7%
47-3013	Helpers--Electricians	Buildings, Energy, Onroad Transport	1,184	(2)	1,103	83	83	12.3%
47-3015	Helpers--Pipelayers, Plumbers, Pipefitters, and Steamfitters	Buildings	700	1	665	35	36	9.2%
47-4011	Construction and Building Inspectors	Buildings, Energy	367	(14)	340	42	34	4.2%

SOC Code	Occupation	Relevant Sector	2025 Supply	2025 Demand		Potential Shortage or Surplus		
			Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
49-2093	Electrical and Electronics Installers and Repairers, Transportation Equipment	Buildings, Energy	91	(2)	83	10	8	5.0%
49-2095	Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	Buildings, Energy	92	(5)	81	15	12	5.3%
49-2096	Electronic Equipment Installers and Repairers, Motor Vehicles	Onroad Transport	119	(6)	122	4	2	1.7%
49-9021	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	Buildings	1,704	7	1,624	72	96	2.1%
49-9031	Home Appliance Repairers	Buildings	183	(2)	169	17	16	5.2%
49-9051	Electrical Power-Line Installers and Repairers	Energy	211	6	192	14	21	2.5%
49-9081	Wind Turbine Service Technicians	Buildings, Energy	5	(1)	5	1	0	5.3%
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	Onroad Transport	381	24	367	-10	14	1.3%

SOC Code	Occupation	Relevant Sector	2025 Supply	2025 Demand		Potential Shortage or Surplus		
			Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
51-2098	Miscellaneous Assemblers and Fabricators	Onroad Transport	2,144	3	2,141	0	44	0.0%
51-8011	Nuclear Power Reactor Operators	Energy	13	(1)	16	-2	-3	4.8%
51-8012	Power Distributors and Dispatchers	Energy	13	(0)	12	1	2	2.3%
51-8013	Power Plant Operators	Energy	22	(1)	20	3	2	2.8%
51-8021	Stationary Engineers and Boiler Operators	Energy	55	(1)	50	6	6	3.6%
51-8031	Water and Wastewater Treatment Plant and System Operators	Wastewater	133	(15)	123	26	14	5.7%
51-8091	Chemical Plant and System Operators	Industry	0	0	0	0	0	0.0%
51-9011	Chemical Equipment Operators and Tenders	Industry	50	2	47	1	4	0.8%
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Offroad Transport	1,457	20	1,425	12	44	0.4%
53-3032	Heavy and Tractor-Trailer Truck Drivers	Offroad Transport	5,782	87	5,761	-66	49	0.7%

SOC Code	Occupation	Relevant Sector	2025 Supply	2025 Demand		Potential Shortage or Surplus		
			Hires	Growth (New Jobs)	Separations	2025 Shortage	2035 Shortage	% 2025 Total Occupational Employment
53-3033	Light Truck Drivers	NWL	5,429	214	4,859	357	672	7.0%
53-3052	Bus Drivers, Transit and Intercity	Onroad Transport	215	6	191	18	26	2.7%
53-5011	Sailors and Marine Oilers	Offroad Transport	1,387	(21)	1,420	-12	-11	-0.5%
53-5021	Captains, Mates, and Pilots of Water Vessels	Offroad Transport	1,133	(13)	1,139	7	11	0.4%
53-5031	Ship Engineers	Offroad Transport	762	(11)	791	-18	-16	1.5%
53-7021	Crane and Tower Operators	Offroad Transport	353	0	335	17	21	3.6%
53-7041	Hoist and Winch Operators	Offroad Transport	5	0	5	0	0	0.0%
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	NWL, Offroad Transport	13,105	84	13,360	-339	-204	2.8%
53-7081	Refuse and Recyclable Material Collectors	Waste	361	5	320	36	45	7.8%
53-7121	Tank Car, Truck, and Ship Loaders	Offroad Transport	20	(0)	22	-1	-1	3.2%

Top Certifications

Table C15: EV Maintenance

Certification
Electric Vehicle Infrastructure Training Program (EVITP)
EVF Certification
ASE xEV Certification
Automotive Service Excellence (ASE) Certification
ASE Advanced Engine Performance Certification
ASE Medium-Heavy Truck Certification
Automobile Parts Specialist Certification
ASE Auto Maintenance and Light Repair Certification
ASE Automobile Service Consultant

Table C16: Energy Auditor

Certification
BPI Home Energy Professional Energy Auditor certification
CEA
Home Energy Professional (HEP) Energy Auditor
Building Energy Assessment Professional (BEAP) certification
Home Energy Auditor InterNACHI
Certified Industrial Energy Auditor (CEIA)
LEED Accredited Professional (AP)
Certified Energy Manager
Building Energy Modeling Professional Certification
Certified Electrical Safety Compliance Professional
Certified Building Commissioning Professional
Professional Engineer (PE) License
Operator Certification
System Operator Certification

Table C17: Construction Laborer

Certification
10-Hour Occupational Safety and Health Administration (OSHA) General Industry Card
Commercial Driver's License (CDL)
CDL Class A License
30-Hour OSHA General Industry Card
NICET Certification (National Institute for Certification In Engineering Technologies)
OSHA Certification
Flagger Certification
ASNT Non-Destructive Tester
10-Hour OSHA Construction Card
Certified Crane Operator
Tanker And Hazmat Combo X Endorsement
Hazmat Endorsement
Tanker Endorsement
Forklift Certification
CDL Class C License
National Center For Construction Education & Research (NCCER) Core Curriculum
NCCER Construction Craft Laborer

Table C18: Rooftop Solar

Certification
NABCEP PVIP Certification
Photovoltaics Installer/Designer (PV2) certification
PVIP Board Certification
PV Installer Specialist (PVIS) Board Certification
PV Technical Sales (PVTS) Board Certification
NABCEP Solar Installation Company Accreditation
SEI Solar Professionals Certificate Program (SPCP)
OSHA Construction Safety for Solar Installers
30-Hour OSHA General Industry Card
10-Hour OSHA General Industry Card
NCCER Electrical
NCCER Solar Photovoltaics

Table C19: Heat Pump

Certification
EPA Section 608 Technician Certification
North American Technician Excellence (NATE) Certification with Heat Pump Installation Specialty
NATE Certification with Heat Pump Service Specialty
HVAC Excellence Heat Pump Service
HVAC Excellence Heat Pump Installer
HVAC Excellence Employment
Ready Heat Pump Certification
EPA Universal Certification
NCCER Certification
3rd Class Power Engineer Certificate
EPA 608 Technician Certification
10-Hour OSHA General Industry Card
HVAC Certification

Table C20: HVAC

Certification
EPA 608 Technician Certification
EPA 608 Certification
HVAC Excellence Certification
NATE Certification
Refrigeration Service Engineers Society (RSES) Certification
HVAC/R Certification
EPA Universal Certification
HVAC Excellence Professional Level Certification
Master HVAC License
10-Hour OSHA General Industry Card
30-Hour OSHA General Industry Card

Table C21: Farmers

Certification
Pesticide Applicator License
Accredited Farm Manager (AFM)

Table C22: Landscapers

Certification
Landscape Industry Certified (LIC) Programs (NALP)
Landscape Industry Certified Horticultural Technician (LIC-HT)
Landscape Industry Certified Lawn Care Technician (LIC-LCT)
Certified Landscape Irrigation Auditor (CLIA)
Certified Irrigation Technician (CIT)
Certified Landscape Irrigation Water Manager
Certified Arborist (ISA):
Certified Professional Landscape Designer (CPLD)
Certified Horticultural Technician (CHT)
Pesticide Applicator License
CDL
CDL Class B License
Herbicide Applicator License

Table C23: Electricians

Certification
Certified Electrical Safety Compliance Professional (CESCP)
Master Electrician Certificate
Certified Electrical Safety Worker (CESW)
Electrical Project Management Institute (EPMI) Certification
Certified Electrical Safety Technician (CEST)
Journeyman Electrician License
Certified Energy Manager
LEED Green Associate
NCCER Solar Photovoltaics
Apprentice Electrician

Certification
Green Energy Certification
NCCER Electrical
NCCER Pipeline Electrical & Instrumentation
NICET Certification (National Institute For Certification In Engineering Technologies)
NICET Electrical Power Testing

Table C24: Electrical Engineers

Certification
Bachelor of Science (BS), Electrical Engineering
Bachelor of Engineering (BEng)
PE License
Certified Energy Manager (CEM)
Certified Automation Professional (CAP)
National Institute for Certification in Engineering Technologies (NICET)
LEED Accredited Professional (AP)
Project Management Professional Certification
Certified Information Systems Security Professional
Institute of Electrical and Electronics Engineers (IEEE)
Engineer in Training (EIT)
Certified Power Quality Professional

Table C25: Heavy Tractor-Trailer Drivers

Certification
CDL
CDL Class A License
CDL Class B License
Tanker Endorsement
Transportation Worker Identification Credential (TWIC) Card
Hazmat Endorsement
Tanker And Hazmat Combo X Endorsement
Forklift Certification
CDL Class C License

Certification
Doubles Endorsement
DOT Certification
Triples Endorsement
Hazardous Materials Certification
Certified Crane Operator
Flagger Certification
Pallet Jack Certification

Table C26: Bus Drivers/Transit

Certification
CDL
Passenger Endorsement
CDL Class B License
Cardiopulmonary Resuscitation (CPR) Certification
First Aid Certification
CDL Class A License
Automated External Defibrillator (AED) Certification
CDL Class C License

Educational/Training Programs

Table C27: EV Maintenance

Institution	Type	County	Course/Program
Naval Facilities Engineering Command Mid-Atlantic	Apprenticeship	Norfolk city	Alternative Fuel Vehicle Technology/Technician
Hampton Roads Sanitation District (HRSD)	Apprenticeship	Virginia Beach city	Alternative Fuel Vehicle Technology/Technician
Harvey's Garage	Apprenticeship	Virginia Beach city	Alternative Fuel Vehicle Technology/Technician
EDTUNITY Institute	VA Works	Norfolk city	Electric Vehicle Technician Operations & Maintenance (ETAi Certification)
EDTUNITY Institute	VA Works	Norfolk city	Electric Vehicle Technician Credential

Table C28: Energy Auditor

Institution	Type	County	Course/Program
Paul D Camp Community College	Community College	Suffolk city	Environmental Control Technologies/Technicians, Other

Table C29: Construction Laborer

Institution	Type	County	Course/Program
Tidewater Community College	Community College	Norfolk City	Construction Trades, General
RenewableWorks	Apprenticeship	Chesapeake city	Construction Laborer
Virginia Peninsula Community College	Community College	James City County	Construction Laborer
George Nice and Sons	Apprenticeship	James City County	Construction Laborer
Toano Contractors	Apprenticeship	James City County	Construction Laborer
Richmond Redevelopment & Housing Authority	Apprenticeship	Richmond city	Construction Laborer
DEPCOM Power, INC	Apprenticeship	Suffolk city	Construction Laborer
New Horizon Education Center	Apprenticeship	Virginia Beach city	Construction Laborer
George Nice and Sons	Apprenticeship	James City County	Construction/Heavy Equipment/Earthmoving Equipment Operation.
City of Newport News	Apprenticeship	Newport News city	Construction/Heavy Equipment/Earthmoving Equipment Operation.
DEPCOM Power, INC	Apprenticeship	Suffolk city	Construction/Heavy Equipment/Earthmoving Equipment Operation.
New Horizons Regional Education Centers LWDA	VA Works	Newport News city	Construction Technology Program
Chesapeake Career Center	CTE	Chesapeake City	Building Trades
The College & Career Academy at Pruden	CTE	Suffolk city	Utility/Heavy Construction
New Horizons CTE	CTE	Newport News	Building Construction

Table C30: Rooftop Solar

Institution	Type	County	Course/Program
Virginia Peninsula Community College	Community College	Hampton city	Solar Panel Installer Training
Paul D Camp Community College	Community College	Suffolk city	CSC Energy Technology
Rappahannock Community College	Community College	Gloucester County	SHINE Solar PV Installation Technician Certification
Centura College	CTE	Newport News city	Solar Technician Training program
Norfolk State University	University	Norfolk city	Solar Energy Training
Centura College	CTE	Newport News city	Solar Technician Installer Certificate
New Horizons Regional Education Centers LWDA	CTE	Newport News city	Electricity and Renewable Energy
Hampton City Schools	CTE High School	Hampton city	Energy

Table C31: Heat Pump and HVAC

Institution	Type	County	Course/Program
Centura College-Newport News	CTE	Newport News	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Fortis College-Norfolk	Trade School	Norfolk	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Tidewater Tech-Trades	CTE	Norfolk	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Advanced Technology Institute	Technical Institute	Virginia Beach city	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Virginia Peninsula Community College	Community College	Hampton city	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)

Institution	Type	County	Course/Program
Centura College-Virginia Beach	CTE	Virginia Beach	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Centura College-Chesapeake	CTE	Chesapeake	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Paul D Camp Community College	Community College	Franklin	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
Rappahannock Community College	Community College	Gloucester County	Heating, Air Conditioning, Ventilation and Refrigeration Maintenance Technology/Technician (HAC, HACR, HVAC, HVACR)
ABC-VA	Apprenticeship	Chesapeake	HVAC Technician
Norfolk Technical Center	Apprenticeship	Norfolk city	HVAC Technician
Hunter Mechanical LLC	Apprenticeship	Hampton city	HVAC Technician
Southeastern Mechanical Inc.	Apprenticeship	CHESAPEAKE	HVAC Technician
Trane	Apprenticeship	CHESAPEAKE	HVAC Technician
Chesapeake Controls,Inc.	Apprenticeship	CHESAPEAKE	HVAC Technician
Tri Star Electric, Inc.	Apprenticeship	CHESAPEAKE	HVAC Technician
Waterfront Electric, Inc.	Apprenticeship	CHESAPEAKE	HVAC Technician
Hobbs Mechanical	Apprenticeship	Chesapeake city	HVAC Technician
Colonialwebb Contractors	Apprenticeship	Chesapeake city	HVAC Technician
VP Refrigeration LLC	Apprenticeship	Chesapeake city	HVAC Technician
Watson Electrical Construction, LLC	Apprenticeship	Chesapeake city	HVAC Technician
Temple Heating & Air	Apprenticeship	Chesapeake city	HVAC Technician
JRC Mechanical, LLC	Apprenticeship	Chesapeake city	HVAC Technician
Tidewater Air Balance, Inc	Apprenticeship	Chesapeake city	HVAC Technician
Quality Plumbing & Mechanical, Inc.	Apprenticeship	Chesapeake city	HVAC Technician
Arrieta Construction, Inc.	Apprenticeship	Gloucester County	HVAC Technician
Hodges & Bryant, LLC	Apprenticeship	Gloucester County	HVAC Technician
Hampton City Schools	Apprenticeship	Hampton city	HVAC Technician

Institution	Type	County	Course/Program
CST Mechanical, Inc.	Apprenticeship	Hampton city	HVAC Technician
Newport News Shipbuilding	Apprenticeship	Newport News city	HVAC Technician
Mechanical Resources Inc.	Apprenticeship	Newport News city	HVAC Technician
Riverside Regional Medical Center	Apprenticeship	Newport News city	HVAC Technician
City of Newport News	Apprenticeship	Newport News city	HVAC Technician
Masters Mechanical Corporation	Apprenticeship	Newport News city	HVAC Technician
Gault Electric LLC	Apprenticeship	Newport News city	HVAC Technician
Newport News Public Schools	Apprenticeship	Newport News city	HVAC Technician
Southeastern Virginia P.H.C.C.	Apprenticeship	Newport News city	HVAC Technician
Best Repair Company, Inc.	Apprenticeship	NORFOLK	HVAC Technician
Naval Facilities Engineering Command Mid-Atlantic	Apprenticeship	Norfolk city	HVAC Technician
JAC Plumbing, Heating & Air Conditioning Industry - Local 110	Apprenticeship	Norfolk city	HVAC Technician
Norfolk Air Heating & Cooling Inc.	Apprenticeship	Norfolk city	HVAC Technician
Old Dominion University - Maintenance/HVAC	Apprenticeship	Norfolk city	HVAC Technician
Sentara Health Systems	Apprenticeship	Norfolk city	HVAC Technician
JRC Services, LLC	Apprenticeship	Norfolk city	HVAC Technician
J.F. Whitlow Jr. & Sons	Apprenticeship	PORTSMOUTH	HVAC Technician
Philbrick Inc.	Apprenticeship	PORTSMOUTH	HVAC Technician
Elizabeth River Mechanical, LLC	Apprenticeship	Portsmouth city	HVAC Technician
D.E. Kirby Inc.	Apprenticeship	Portsmouth city	HVAC Technician
Norfolk Naval Shipyard	Apprenticeship	Portsmouth city	HVAC Technician
Bay Mechanical Inc	Apprenticeship	VIRGINIA BEACH	HVAC Technician
Davken Mechanical	Apprenticeship	VIRGINIA BEACH	HVAC Technician
Guy Smith Heating & Cooling	Apprenticeship	Virginia Beach city	HVAC Technician
Coolsys Commercial & Industrial Solutions, Inc.	Apprenticeship	Virginia Beach city	HVAC Technician
Applied Mechanical Resources, Inc.	Apprenticeship	Virginia Beach city	HVAC Technician
United Property Associates	Apprenticeship	Virginia Beach city	HVAC Technician
Davcon, Inc.	Apprenticeship	Virginia Beach city	HVAC Technician
Thermo-Trol Systems, Inc.	Apprenticeship	Virginia Beach city	HVAC Technician

Institution	Type	County	Course/Program
Ragan Sheet Metal	Apprenticeship	Virginia Beach city	HVAC Technician
Hutchinson Mechanical Energy Specialists	Apprenticeship	Virginia Beach city	HVAC Technician
Mechanical Service Solutions Corp	Apprenticeship	Virginia Beach city	HVAC Technician
American Mechanical	Apprenticeship	Virginia Beach city	HVAC Technician
Sensible Solutions Hvac Services, LLC	Apprenticeship	Virginia Beach city	HVAC Technician
Cox-Powell Corporation	Apprenticeship	Williamsburg city	HVAC Technician
The Colonial Williamsburg Foundation	Apprenticeship	Williamsburg city	HVAC Technician
County of York	Apprenticeship	York County	HVAC Technician
York County Schools	Apprenticeship	York County	HVAC Technician
Hampton University	University	Hampton city	HVAC Certificate
Tidewater Community College	Community College	Portsmouth	Certificate - Air Conditioning & Refrigeration
Virginia Peninsula Community College	Community College	Hampton city	Air Conditioning and Refrigeration Career Studies Certificate
Virginia Peninsula Community College	Community College	Hampton city	Air Conditioning and Refrigeration Certificate
Virginia Peninsula Community College	Community College	Hampton city	HVAC Technician
Virginia Peninsula Community College	Community College	Hampton city	Associate of Applied Science – Specialization in HVAC-R Technology
Paul D Camp Community College	Community College	Suffolk city	Career Studies Certificate HVAC
Rappahannock Community College	Community College	Gloucester County	HVAC Career Studies Certificate
Rappahannock Community College	Community College	Gloucester County	Advanced Heating, Ventilation, and Air Conditioning (AHVAC) Career Studies Certificate
Centura College	CTE	Newport News city	HVAC Diploma
Hampton University	University	Hampton city	HVAC Certificate
Advanced Technology Institute	Technical Institute	Virginia Beach city	HVAC and Refrigeration
New Horizons Regional Education Centers LWDA	CTE	Newport News city	HVAC
Tidewater Tech	CTE	Norfolk city	HVAC

Institution	Type	County	Course/Program
Virginia Technical Academy	HVAC	Newport News city	HVAC
Chesapeake Career Center	CTE	Chesapeake City	HVAC
Portsmouth Public Schools	CTE High School	Portsmouth city	HVAC
New Horizons CTE	CTE	Newport News	HVAC
Virginia Beach Technical and Career Education Center	CTE	Virginia Beach city	HVAC

Table C32: Farming

Institution	Type	County	Course/Program
Hampton City Schools	CTE	Hampton city	Agriculture, Food, and Natural Resources

Table C33: Landscaping

Institution	Type	County	Course/Program
Tidewater Community College	Community College	Chesapeake	Landscape Management - Career Studies Certificate
Virginia Beach Technical and Career Education Center	CTE	Virginia Beach city	Landscape Design and Management

Table C34: Electricians

Institution	Type	County	Course/Program
Centura College-Norfolk	CTE	Norfolk	Electrician
Tidewater Community College	Community College	Chesapeake	Electrician
Paul D Camp Community College	Community College	Franklin	Electrician
Rappahannock Community College	Community College	Gloucester County	Electrician
IBEW Local 80	Apprenticeship	Chesapeake	Electrician
IBEW Local 1340	Apprenticeship	Newport News	Electrician
Independent Electrical Contractors	Apprenticeship	Chesapeake	Electrician
ABC-VA	Apprenticeship	Chesapeake	Electrician
Tecnico	Apprenticeship	CHESAPEAKE	Electrician
Plasser American Corporation	Apprenticeship	CHESAPEAKE	Electrician
It's Electric, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Southeastern Mechanical Inc.	Apprenticeship	CHESAPEAKE	Electrician
Chesapeake Controls,Inc.	Apprenticeship	CHESAPEAKE	Electrician

Institution	Type	County	Course/Program
HBH Industrial Services, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Mr. Electric of chesapeake	Apprenticeship	CHESAPEAKE	Electrician
Tri Star Electric, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Waterfront Electric, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Best Electric Company	Apprenticeship	CHESAPEAKE	Electrician
L.E. Ballance Electrical Service, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Mac's Electric, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Highway Electric, Inc.	Apprenticeship	CHESAPEAKE	Electrician
Power Electric Company	Apprenticeship	Chesapeake city	Electrician
Branham Electric Corporation	Apprenticeship	Chesapeake city	Electrician
A - Plus Electrical Services LLC	Apprenticeship	Chesapeake city	Electrician
Argo Electrical Group	Apprenticeship	Chesapeake city	Electrician
M-3 Electric	Apprenticeship	Chesapeake city	Electrician
Colonialwebb Contractors	Apprenticeship	Chesapeake city	Electrician
Hampton Roads Executive Airport	Apprenticeship	Chesapeake city	Electrician
Current Electrical Contracting	Apprenticeship	Chesapeake city	Electrician
Get Lit Electrical, LLC.	Apprenticeship	Chesapeake city	Electrician
Watson Electrical Construction, LLC	Apprenticeship	Chesapeake city	Electrician
Quality Electric Contracting Inc.	Apprenticeship	Chesapeake city	Electrician
Jrc Mechanical, LLC	Apprenticeship	Chesapeake city	Electrician
Premier Electrical Services Inc.	Apprenticeship	Chesapeake city	Electrician
R.F. Knight Electric Inc.	Apprenticeship	Chesapeake city	Electrician
Quality Plumbing & Mechanical, Inc.	Apprenticeship	Chesapeake city	Electrician
Associated Mechanical Companies, Inc.	Apprenticeship	Chesapeake city	Electrician
Freedom Electric, Inc.	Apprenticeship	Chesapeake city	Electrician
Amee Bay	Apprenticeship	Chesapeake County	Electrician
Highground Services, Inc.	Apprenticeship	Franklin city	Electrician
North River Construction	Apprenticeship	Gloucester County	Electrician
Unique Environmental Energy Services Inc.	Apprenticeship	Gloucester County	Electrician
Hunter Mechanical LLC	Apprenticeship	Hampton city	Electrician
Hampton City Schools	Apprenticeship	Hampton city	Electrician
CST Mechanical, Inc.	Apprenticeship	Hampton city	Electrician

Institution	Type	County	Course/Program
AAA Electrical Contracting	Apprenticeship	Hampton city	Electrician
Systems East Inc.	Apprenticeship	Hampton city	Electrician
Harbor Construction Co.	Apprenticeship	Hampton city	Electrician
Hatchett Electrical Services Inc.	Apprenticeship	Isle of Wight County	Electrician
Triad Electrical Solutions	Apprenticeship	Isle of Wight County	Electrician
Ethan Capps, LLC	Apprenticeship	Isle of Wight County	Electrician
Community Electric Cooperative	Apprenticeship	Isle of Wight County	Electrician
Luxterra Electrical, Inc.	Apprenticeship	James City County	Electrician
Phase 3 Electrical Contracting LLC	Apprenticeship	Newport News city	Electrician
MorLite Electric LLC	Apprenticeship	Newport News city	Electrician
Mallory Electric Company	Apprenticeship	Newport News city	Electrician
Atlantic Wiring Group	Apprenticeship	Newport News city	Electrician
Rand Enterprises, Inc.	Apprenticeship	Newport News city	Electrician
Bay Electric Co., Inc.	Apprenticeship	Newport News city	Electrician
Jaswal Corp	Apprenticeship	Newport News city	Electrician
Newport News Shipbuilding	Apprenticeship	Newport News city	Electrician
Gregory Power Services	Apprenticeship	Newport News city	Electrician
Mechanical Resources Inc.	Apprenticeship	Newport News city	Electrician
Virginia Technical Academy	Apprenticeship	Newport News city	Electrician
Go Green Electric Inc	Apprenticeship	Newport News city	Electrician
Riverside Regional Medical Center	Apprenticeship	Newport News city	Electrician
Herm Technologies	Apprenticeship	Newport News city	Electrician
The Mariners' Museum & Park	Apprenticeship	Newport News city	Electrician
City of Newport News	Apprenticeship	Newport News city	Electrician
Masters Mechanical Corporation	Apprenticeship	Newport News city	Electrician
Gault Electric LLC	Apprenticeship	Newport News city	Electrician
David R. Hall Inc.	Apprenticeship	Newport News city	Electrician
Canon Virginia Inc.	Apprenticeship	Newport News city	Electrician
Fresh Start Electrical, LLC	Apprenticeship	Newport News city	Electrician
D T Electric LLC	Apprenticeship	Newport News city	Electrician
JATC Hampton Roads Electrical Industry – Local 1340	Apprenticeship	Newport News city	Electrician

Institution	Type	County	Course/Program
Advanced Electrical Service	Apprenticeship	Newport News city	Electrician
Dorey Electric Company	Apprenticeship	NORFOLK	Electrician
RG Electric Company	Apprenticeship	NORFOLK	Electrician
City Wide Services	Apprenticeship	NORFOLK	Electrician
Best Repair Company, Inc.	Apprenticeship	NORFOLK	Electrician
CPI Services	Apprenticeship	NORFOLK	Electrician
Naval Facilities Engineering Command Mid-Atlantic	Apprenticeship	Norfolk city	Electrician
Egger Electric, INC	Apprenticeship	Norfolk city	Electrician
IE Jordan Electrical Services	Apprenticeship	Norfolk city	Electrician
COVA Electric	Apprenticeship	Norfolk city	Electrician
Norfolk Air Heating & Cooling Inc.	Apprenticeship	Norfolk city	Electrician
Professional Heating & Cooling	Apprenticeship	Norfolk city	Electrician
Sentara Health Systems	Apprenticeship	Norfolk city	Electrician
E & P Electrical Contracting Co.	Apprenticeship	Norfolk city	Electrician
I-A-Electric	Apprenticeship	Norfolk city	Electrician
Core Contracting Incorporated	Apprenticeship	Norfolk city	Electrician
JRC Services, LLC	Apprenticeship	Norfolk city	Electrician
City Of Norfolk Facility Maintenance	Apprenticeship	Norfolk city	Electrician
BAE Systems Norfolk Ship Repair	Apprenticeship	Norfolk city	Electrician
Colonna's Shipyard, Inc.	Apprenticeship	Norfolk city	Electrician
Mike & Mike Services	Apprenticeship	Norfolk city	Electrician
JATC Tidewater Electrical Industry - Local 80	Apprenticeship	Norfolk city	Electrician
Brite Electric	Apprenticeship	Norfolk city	Electrician
Hutton Power & Light	Apprenticeship	Norfolk city	Electrician
Blackout electric, inc	Apprenticeship	Norfolk city	Electrician
(VA) Fleet Readiness Center Mid-Atlantic and Affiliates	Apprenticeship	Norfolk city	Electrician
D.F. Lentz Electric	Apprenticeship	Poquoson city	Electrician
R.E.W. Corporation	Apprenticeship	PORTSMOUTH	Electrician
Electron	Apprenticeship	Portsmouth city	Electrician
Fee Electrical Services, INC	Apprenticeship	Portsmouth city	Electrician

Institution	Type	County	Course/Program
Norfolk Naval Shipyard	Apprenticeship	Portsmouth city	Electrician
Electrical Automation Company, LLC	Apprenticeship	SUFFOLK	Electrician
Freeman & Associates, Inc.	Apprenticeship	Suffolk city	Electrician
Integrated Electrical Services Inc.	Apprenticeship	Suffolk city	Electrician
Mid-Atlantic Academy of Skilled Trade (formerly Allfirst)	Apprenticeship	Suffolk city	Electrician
Current Contracting	Apprenticeship	Suffolk city	Electrician
C. & S. Electrical Design, LLC	Apprenticeship	Suffolk city	Electrician
Professional Services Unlimited	Apprenticeship	Suffolk city	Electrician
Coggin Electric	Apprenticeship	Surry County	Electrician
J. C. Driskill, Inc.	Apprenticeship	VIRGINIA BEACH	Electrician
Curling Electric	Apprenticeship	VIRGINIA BEACH	Electrician
M & G Electric Corp., T/A Kittrell Elec.	Apprenticeship	VIRGINIA BEACH	Electrician
White Electric Company	Apprenticeship	VIRGINIA BEACH	Electrician
Bay Mechanical Inc	Apprenticeship	VIRGINIA BEACH	Electrician
Hitt Electric Corporation	Apprenticeship	VIRGINIA BEACH	Electrician
Dagan Electric Company LLC	Apprenticeship	VIRGINIA BEACH	Electrician
Virginia Beach Electric Service, Inc.	Apprenticeship	VIRGINIA BEACH	Electrician
Flex Electric	Apprenticeship	VIRGINIA BEACH	Electrician
Poston Electrical Contracting	Apprenticeship	VIRGINIA BEACH	Electrician
Convert Solar	Apprenticeship	Virginia Beach city	Electrician
Hampton Roads Sanitation District (HRSD)	Apprenticeship	Virginia Beach city	Electrician
HII Fleet Support Group LLC	Apprenticeship	Virginia Beach city	Electrician
Paul Walker Electric, LLC	Apprenticeship	Virginia Beach city	Electrician
Mike's Electrical Services	Apprenticeship	Virginia Beach city	Electrician
Coolsys Commercial & Industrial Solutions, Inc.	Apprenticeship	Virginia Beach city	Electrician
Kittrell Electric	Apprenticeship	Virginia Beach city	Electrician
The Atlantic Group, Inc.	Apprenticeship	Virginia Beach city	Electrician
All Weather Contracting, LLC	Apprenticeship	Virginia Beach city	Electrician
Thermo-Trol Systems, Inc.	Apprenticeship	Virginia Beach city	Electrician
Acoustical Sheetmetal Company	Apprenticeship	Virginia Beach city	Electrician
Independent Lighting, Inc.	Apprenticeship	Virginia Beach city	Electrician

Institution	Type	County	Course/Program
Beach Electric, LLC.	Apprenticeship	Virginia Beach city	Electrician
City of Virginia Beach	Apprenticeship	Virginia Beach city	Electrician
Kellam Mechanical	Apprenticeship	Virginia Beach city	Electrician
Electrical Services & Design	Apprenticeship	Virginia Beach city	Electrician
Mechanical Service Solutions Corp	Apprenticeship	Virginia Beach city	Electrician
Va. Beach City Public Schools/Maintenance	Apprenticeship	Virginia Beach city	Electrician
Cox-Powell Corporation	Apprenticeship	Williamsburg city	Electrician
Dynamo Electric Inc.	Apprenticeship	Williamsburg city	Electrician
The Colonial Williamsburg Foundation	Apprenticeship	Williamsburg city	Electrician
James City County Service Authority (Utilities)	Apprenticeship	Williamsburg city	Electrician
Gremac Power & Light, LLC	Apprenticeship	Williamsburg city	Electrician
Baird Electric	Apprenticeship	Williamsburg city	Electrician
K & K Electrical, LLC	Apprenticeship	Williamsburg city	Electrician
County of York	Apprenticeship	York County	Electrician
Walsh Electric Co., Inc.	Apprenticeship	York County	Electrician
Carrick Contracting Corporation	Apprenticeship	York County	Electrician
Tidewater Community College	Community College	Chesapeake	Career Studies Certificate - Electrical Wiring for Technicians
Tidewater Community College	Community College	Chesapeake	Certificate - Electrical Wiring
Virginia Peninsula Community College	Community College	Hampton city	Trades Electrician
Paul D Camp Community College	Community College	Suffolk city	CERT Electricity
Paul D Camp Community College	Community College	Suffolk city	CSC Practical Electrical Technician
Paul D Camp Community College	Community College	Suffolk city	CSC Electrical Technology
Paul D Camp Community College	Community College	Suffolk city	CSC Practical Electrician
Rappahannock Community College	Community College	Gloucester County	Electrical and Instrumentation Technician Career Studies Certificate

Institution	Type	County	Course/Program
Rappahannock Community College	Community College	Gloucester County	Practical Electrical Technician Career Studies Certificate
Rappahannock Community College	Community College	Gloucester County	Electrical and Instrumentation Technician Career Studies Certificate
Centura College	CTE	Norfolk city	Construction Electrician
New Horizons Regional Education Centers LWDA	CTE	Newport News city	Electricity and Renewable Energy
New Horizons Regional Education Centers LWDA	CTE	Newport News city	Electrical Program
QED Systems, Inc. Center for Training and Development	CTE	Norfolk city	Basic Electrician
Virginia Technical Academy	CTE	Newport News city	Electrical
Chesapeake Career Center	CTE	Chesapeake City	Electricity
Hampton City Schools	CTE High School	Hampton city	Architecture and Construction
The College & Career Academy at Pruden	CTE	Suffolk city	Electricity
New Horizons CTE	CTE	Newport News	Electrical and Renewable Energy
Virginia Beach Technical and Career Education Center	CTE	Virginia Beach city	Electricity

Table C35: Electrical Engineers and Electricians

Institution	Type	County	Course/Program
Christopher Newport University	University	Newport News	Electrical, Electronics and Communications Engineering
Old Dominion University	University	Norfolk	Electrical, Electronics and Communications Engineering
Norfolk State University	University	Norfolk	Electrical, Electronics and Communications Engineering
Virginia Peninsula Community College	Community College	Hampton city	Electrical, Electronic, and Communications Engineering Technology/Technician
Paul D Camp Community College	Community College	Franklin	Electrical, Electronic, and Communications Engineering Technology/Technician

Institution	Type	County	Course/Program
Norfolk State University	University	Norfolk	Electrical, Electronic, and Communications Engineering Technology/Technician
Rappahannock Community College	Community College	Gloucester County	Electrical, Electronic, and Communications Engineering Technology/Technician
Paul D Camp Community College	Community College	Suffolk city	CSC Energy Technology
Tidewater Community College	Community College	Chesapeake	Associate of Applied Science - Specialization in Renewable Energy Technologies
Virginia Peninsula Community College	Community College	Hampton city	Electrical Engineering Technology Associate of Applied Science
Virginia Peninsula Community College	Community College	Hampton city	Electrical Engineering Technology Career Studies Certificate
Virginia Peninsula Community College	Community College	Hampton city	Foundations of Electrical Engineering Technology
Rappahannock Community College	Community College	Gloucester County	Practical Electrical Technician Career Studies Certificate
Rappahannock Community College	Community College	Gloucester County	Electrical and Instrumentation Technician Career Studies Certificate
Rappahannock Community College	Community College	Gloucester County	Introduction to Engineering Technology Career Studies Certificate
Advanced Technology Institute	Technical Institute	Virginia Beach city	Electrical Technology
New Horizons Regional Education Centers LWDA	CTE	Newport News city	Electricity and Renewable Energy
New Horizons CTE	CTE	Newport News	Electrical and Renewable Energy

Table C36: Heavy Tractor-Trailer Drivers

Institution	Type	County	Course/Program
Advanced Technology Institute	Technical Institute	Virginia Beach city	Heavy and Tractor-Trailer Truck Drivers
George Nice and Sons	Apprenticeship	James City County	Construction/Heavy Equipment/ Earthmoving Equipment Operation.
City of Newport News	Apprenticeship	Newport News city	Construction/Heavy Equipment/Earthmoving Equipment Operation.
Newport News Public Schools	Apprenticeship	Newport News city	Heavy and Tractor-Trailer Truck Drivers

Institution	Type	County	Course/Program
160 Driving Academy	Private	Norfolk city	CDL
Advanced Technology Institute	Technical Institute	Virginia Beach city	CDL
Dudley's Driving Center Inc.	Private	Newport News city	CDL
Paul D Camp Community College	Community College	Suffolk city	Truck Driver Training
Rappahannock Community College	Community College	Gloucester County	CDL Class A)

Table C37: Bus Drivers Transit

Institution	Type	County	Course/Program
160 Driving Academy	Private	Norfolk city	CDL
Advanced Technology Institute	Technical Institute	Virginia Beach city	CDL
Dudley's Driving Center Inc.	Private	Newport News city	CDL

Appendix D: Engagement

Summary Engagement Efforts

To support the development of the Hampton Roads Comprehensive Climate Action Plan (CCAP), the Hampton Roads Planning District Commission (HRPDC) undertook a comprehensive public and stakeholder engagement process in 2024 and 2025. The primary objective was to solicit meaningful feedback from communities across the 20-locality metropolitan statistical area (MSA) to ensure the final plan reflects regional priorities. Engagement methods were diverse and included two public webinars, meetings with technical and community advisory committees, two public surveys that garnered a combined 497 responses, a specialized survey of 40 transportation professionals, and direct outreach at 11 community events, engaging over 900 residents. A key innovation was the "Climate Cash" activity, a form of participatory budgeting that successfully gamified the feedback process and was well-received by the public at outreach events.

The extensive feedback revealed several clear and consistent priorities for climate action in Hampton Roads. The most dominant themes include:

- **Transportation and Land Use Reform:** Across all surveys and in-person events, there was an urgent and decisive demand to move away from the region's car dependency. This included consistent calls for expanding and improving public transit to make it more reliable and efficient, as well as significant investment in safe and connected infrastructure for walking and biking, such as protected bike lanes and continuous sidewalks.
- **Protection of Natural Systems:** The preservation and expansion of green spaces was a top priority for the community. In Survey II ranking all proposed measures, "Expand urban tree canopy and green space" was the single highest-ranked action item. This sentiment was echoed at community events, where protecting green spaces and creating more living shorelines received significant support.
- **Accelerated Clean Energy Transition:** The community demonstrated strong support for a rapid transition to renewable energy sources. Key priorities included expanding the electric vehicle (EV) charging network and enhancing solar energy programs on residential and commercial buildings.
- **Improved Waste Management:** Residents expressed a desire for improved and more accessible recycling programs and the diversion of recyclable and organic materials from landfills.

The engagement process yielded valuable lessons for future outreach. The "Climate Cash" activity proved to be a highly effective tool for making complex budget topics accessible and engaging. Conversely, technical difficulties with Survey II's ranking question highlighted the need to prioritize user-friendly platforms to avoid respondent frustration. The vast size and diversity of the Hampton Roads MSA also presented a significant challenge, making it difficult to achieve uniform engagement across all communities. The public feedback provides a clear and compelling direction, and the dominant themes identified will be highlighted in the final CCAP.

Overview of Engagement Efforts

At the outset of the CCAP engagement efforts, the HRPDC staff determined that they wanted to accomplish the following deliverables related to the CCAP engagement efforts.

- Press Releases
- Project Information Sheet
- Project Posters (3 – Project Overview)
- Webinar Flyer (2)
- Webinar (2)
- Postcard mailer (2)
- Website content
- Steering Committee – monthly meetings
- Steering Committee – working groups
- HRPDC Community Advisory Committee (CAC)
- HRPDC Regional Transportation Advisory Panel (RTAP)
- Engagement with North Carolina localities
- Technical focus group (TBD)
- Interviews with Tribal governments
- Climate Survey (2)
- Broadcasts
- Engagement through the Steering and Technical Committees
- Paid media
- Community interviews
- Pop-up events
- In-person community events

CCAP Engagement

Webinar I

The first webinar for the Hampton Roads Climate Action Plan was held on January 22, 2025, via Zoom. Approximately 105 people attended the webinar. The webinar provided an overview of the CPRG and why investment in these sorts of sustainability efforts is important for Hampton Roads. Staff answered questions and encouraged attendees to provide their feedback via Survey I, which launched after the webinar.

Many attendees had questions which were detailed in the “Frequently Asked Questions” portion of the HRPDC Climate Action Page website (https://www.hrpdcva.gov/1277/Frequently-Asked-Questions).

A full recording of Webinar I can be found on the HRPDC YouTube (https://youtu.be/rd4YJ0xoAWs?si=TemMDt74gyNqpTC9)

Attendance: 105attendees

As part of the outreach for this webinar, a press release, email invitations, postcards to 10,000 households, and social media promotion were conducted to boost interest and participation.

Webinar II

The second webinar for the Hampton Roads Climate Action Plan was held on June 12, 2025 from 6:00 PM to 7:00 PM via Microsoft Teams. The webinar focused on expanding on potential actions that could be a part of the plan, and encouraged attendees to participate in Survey II, which launched after Webinar II. Attendees had questions surrounding low-income home weatherization programs funded by the Regional Greenhouse Gas Initiative (RGGI), funding (planning vs. implementation), and a recent proposed parking lot solar bill that was vetoed and not signed into law in Virginia’s General Assembly.

A full recording of Webinar II can be found on the HRPDC YouTube (https://youtu.be/aS5ojYF4GbI?si=DmdlAxahZKIlxLTP)

Attendance: Approximately 20 attendees

As part of the outreach for this webinar, a press release, email invitations, and social media promotion were completed to boost interest and participation. The CCAP Engagement team elected not to pursue postcard outreach as part of the advertisement campaign for the 2nd webinar due to low usage rates on the QR codes attached to the first postcards.

Committees

HRPDC/HRTPO (Hampton Roads Transportation Planning Organization) CAC

The CPRG Engagement team met with the HRPDC/HRTPO CAC group at the start of the engagement and socialization process for the CCAP. The CAC is a community-level group comprised of approximately 20 members that provides advisory guidance to the HRPDC/HRTPO on current regional planning priorities and initiatives.

- January 2024 – CAC members were asked to participate in the "HRPDC Committee – Community Outreach Questionnaire"
- April 2024 – CAC members were updated about the CCAP process, and that the HRPDC was also applying for CPRG implementation funds (A full recording of the this meeting can be found on the HRPDC YouTube (https://youtu.be/yLN0CwwCRH4?si=bbjOxUxsk7Mn1pF1&t=367) 0
- June 2025 – CAC members were updated on the proposed measures and actions based on the GHG inventory for the Hampton Roads MSA. They were also provided with a preview of Webinar II and asked to participate in Survey II. A full recording of this meeting can be found on the HRPDC YouTube (https://youtu.be/czhWYjzdEuU?si=sGwxqiXlbSODBOwe&t=2960)

HRTPO RTAP

RTAP is composed of representatives of major business and industry groups, employers, shopping destinations, institutions of higher education, military installations, hospitals, health care centers, public transit entities, and any other groups identified as necessary to provide ongoing advice to the regional planning process required pursuant to §33.2-286 of the Code of Virginia on the long-term vision for a multimodal regional public transit network in Hampton Roads.

- The CPRG Engagement team presented on the Climate Action Plan on June 16, 2025, at a meeting with approximately 50 members and stakeholders. RTAP was asked to provide feedback on the plan regarding the transportation sector, and specifically the adoption of low and zero-emission vehicles (LEV/ZEVs) and investments in public transit.

HRTPO Transportation Technical Advisory Committee (TTAC)

TTAC comprises about 100 members and provides recommendations and technical support to the HRTPO Board on matters concerning the transportation planning and programming process within the Metropolitan Planning Area.

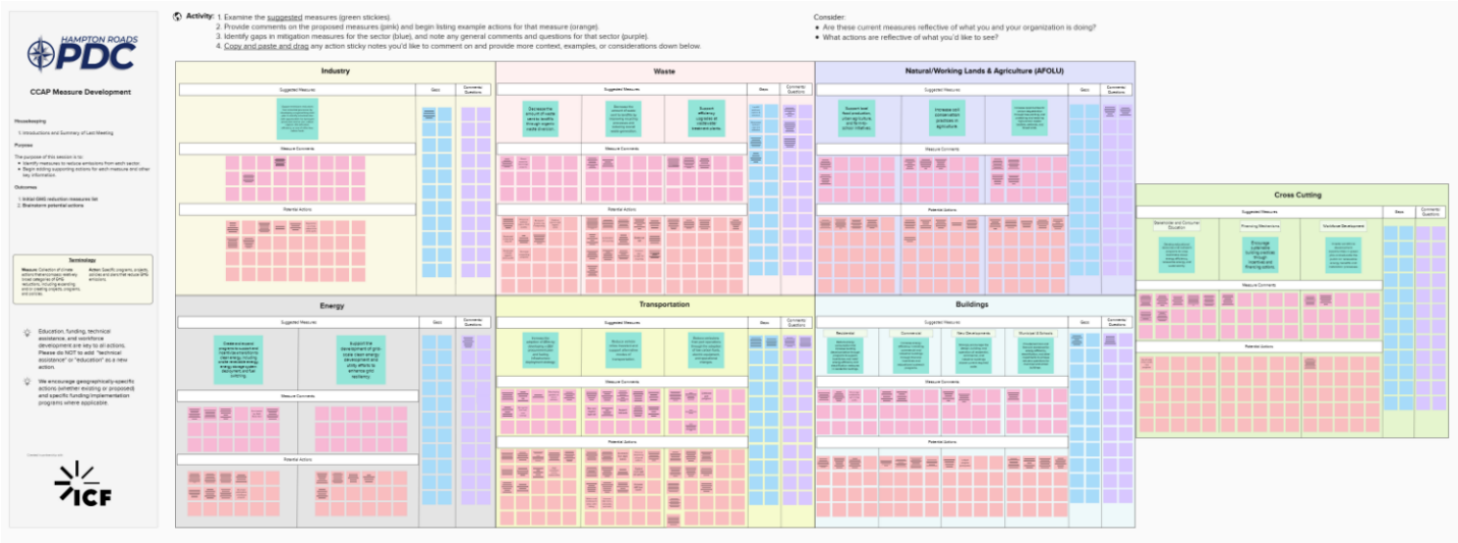
- The CCAP Engagement Team presented on the Transportation measures at the September 3, 2025, TTAC meeting and asked members and stakeholders to provide feedback.

CCAP Steering Committee

The CCAP Steering Committee guided the planning process. The committee is comprised of about 49 members, including technical professionals from the Hampton Roads MSA, state agencies, and regional stakeholders. The Committee participated in the following:

- Regular meetings to discuss and provide feedback on the current status of the planning grant
- A Mural Board activity to determine the potential actions and measures related to the plan
- Review of report drafts
- Feedback on different groups to engage with throughout the process
- Members provided the CCAP Engagement Team with insights on who to connect with, how localities would perceive various measures, and how feasible actions may be.

Figure D1: Screenshot of the Mural Board activity in which the Steering Committee participated



Public Information Officer (PIO) Workgroup

The CCAP Engagement team presented to the HRPDC PIO workgroup on May 27, 2025, to discuss the Climate Action Plan and encourage members to share Survey II and the Climate Action Plan with their respective stakeholders and communication channels. Additionally, the HRPDC PIO emailed the PIOs from localities with less respondents on the survey to encourage more participation.

Survey I

Survey I focused on ascertaining participants' level of knowledge about GHG emissions, the sectors they were most concerned about, and how potential actions were perceived.

For a full breakdown of results, please see the attachments.

For this survey, the CCAP Engagement team used Microsoft Forms.

Results

- Survey I had 281 total respondents
- Top localities to respond: Norfolk (72), Virginia Beach (48), and Newport News (41)

Figure D2: Survey I: Respondent Ages

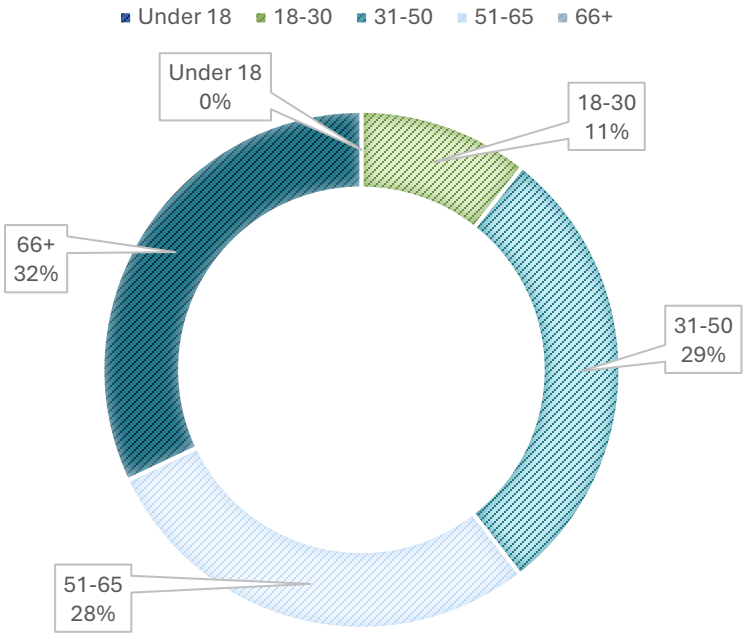


Figure D3: Survey I: Respondent Household Income

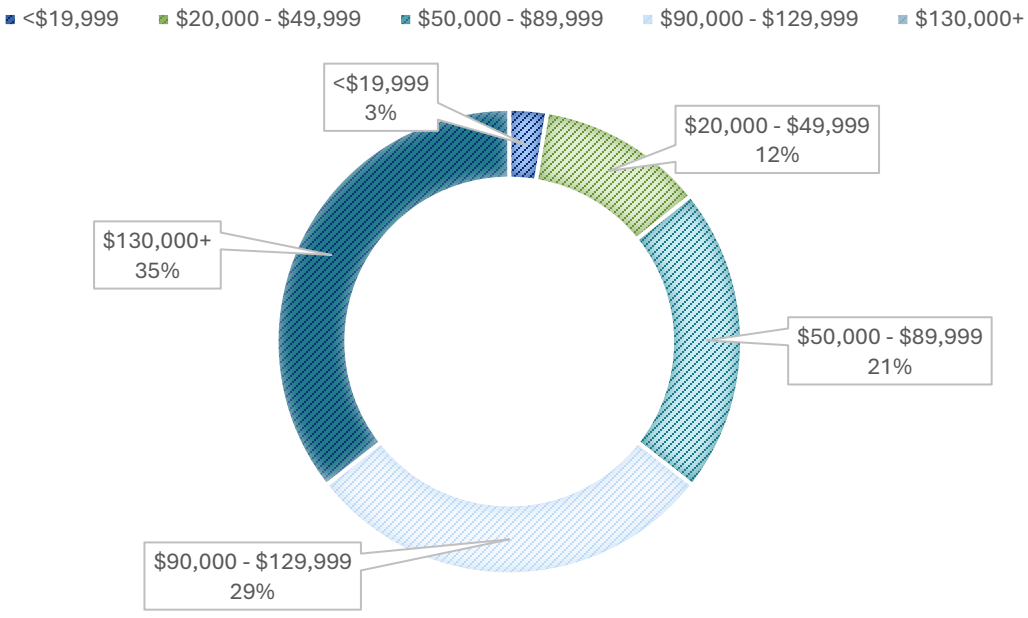


Figure D4: Survey I: What level of knowledge do you have about greenhouse gas emissions, where they come from, and how they impact our daily lives and our climate?

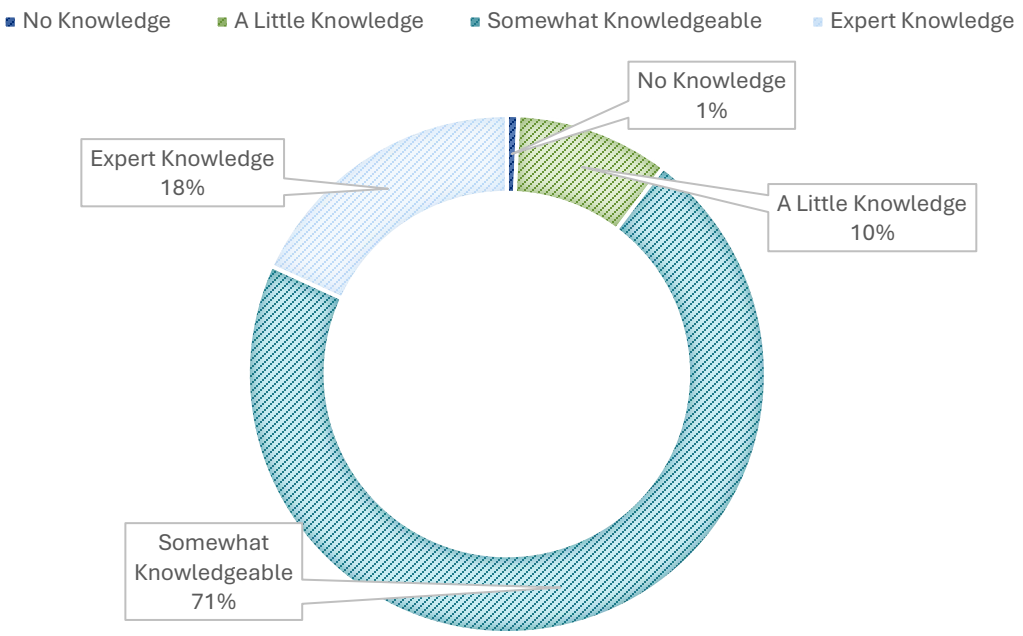


Figure D5: Survey I: How concerned are you about the following climate-related hazards?

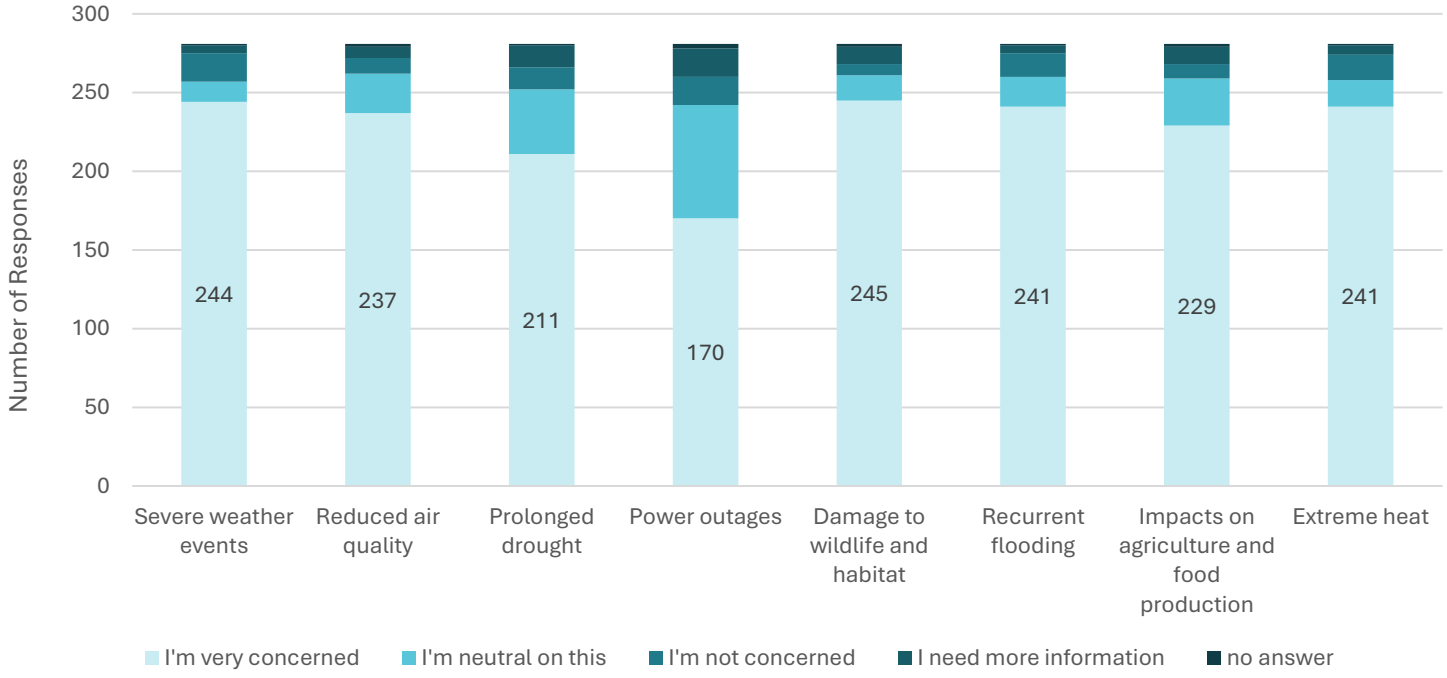


Figure D6: Survey I: What are your top priorities to help reduce climate change impacts? Select all options that resonate with you

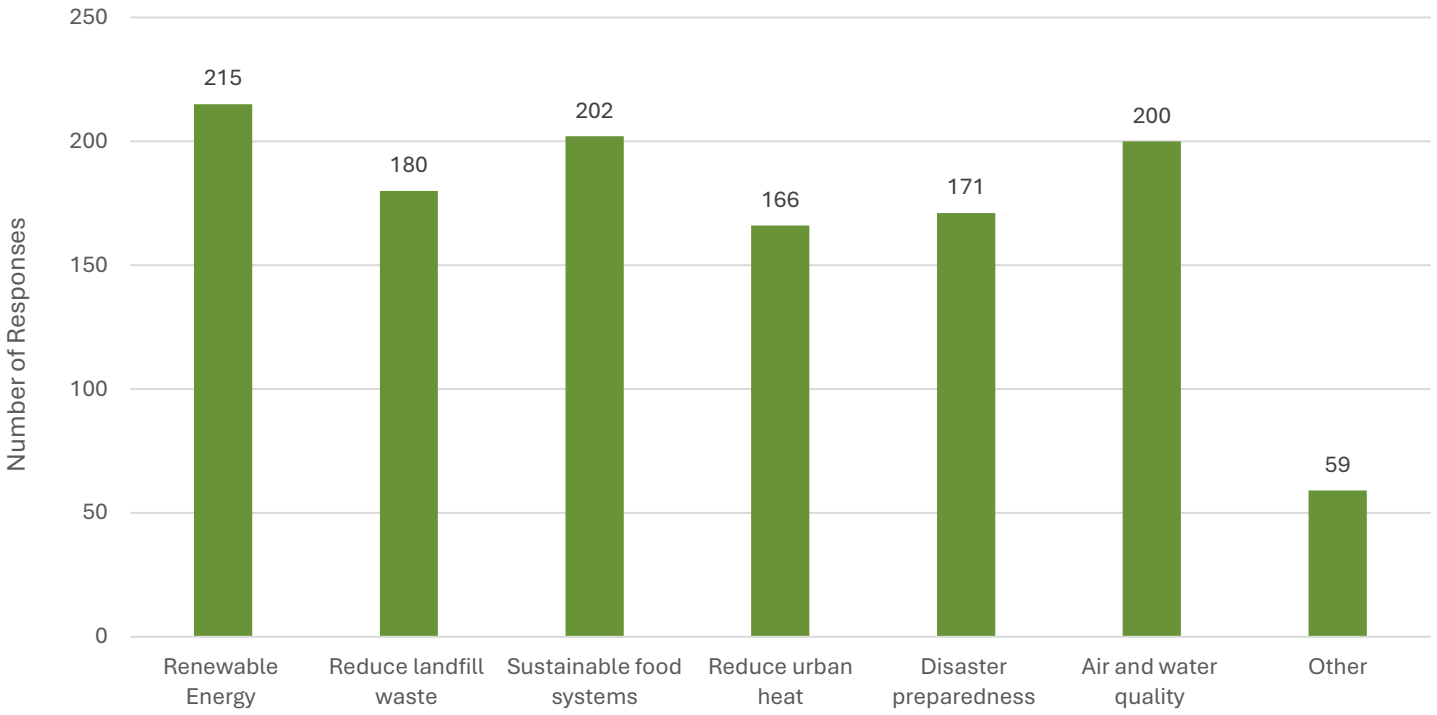


Figure D7: Survey I: Six sectors have been identified for reducing greenhouse gas emissions as part of this process. Please rank these sectors, with the most important at the top and the least important at the bottom

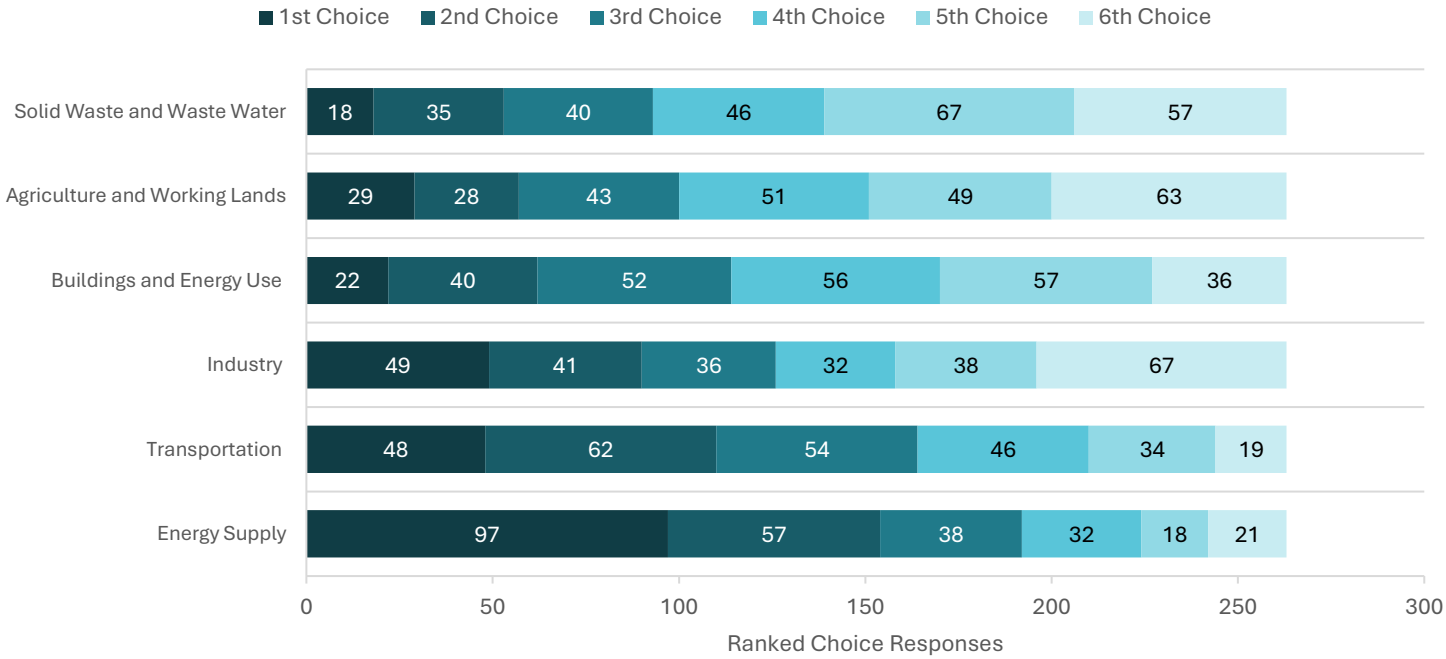


Figure D8: Survey I: What actions are you already taking to help reduce emissions? Select all that apply

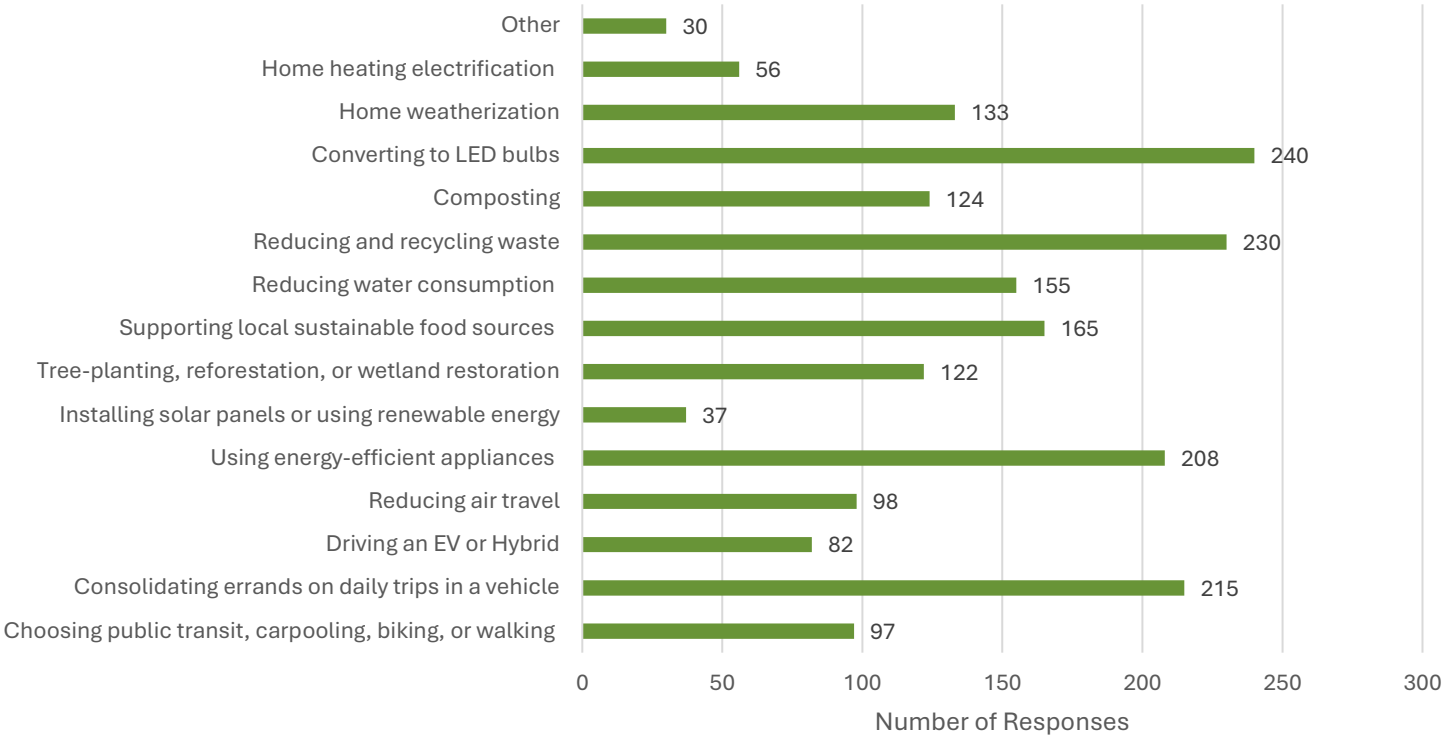


Figure D9: Survey I: What barriers, if any, are preventing you from engaging in any of the above greenhouse gas reduction activities? Select all that apply

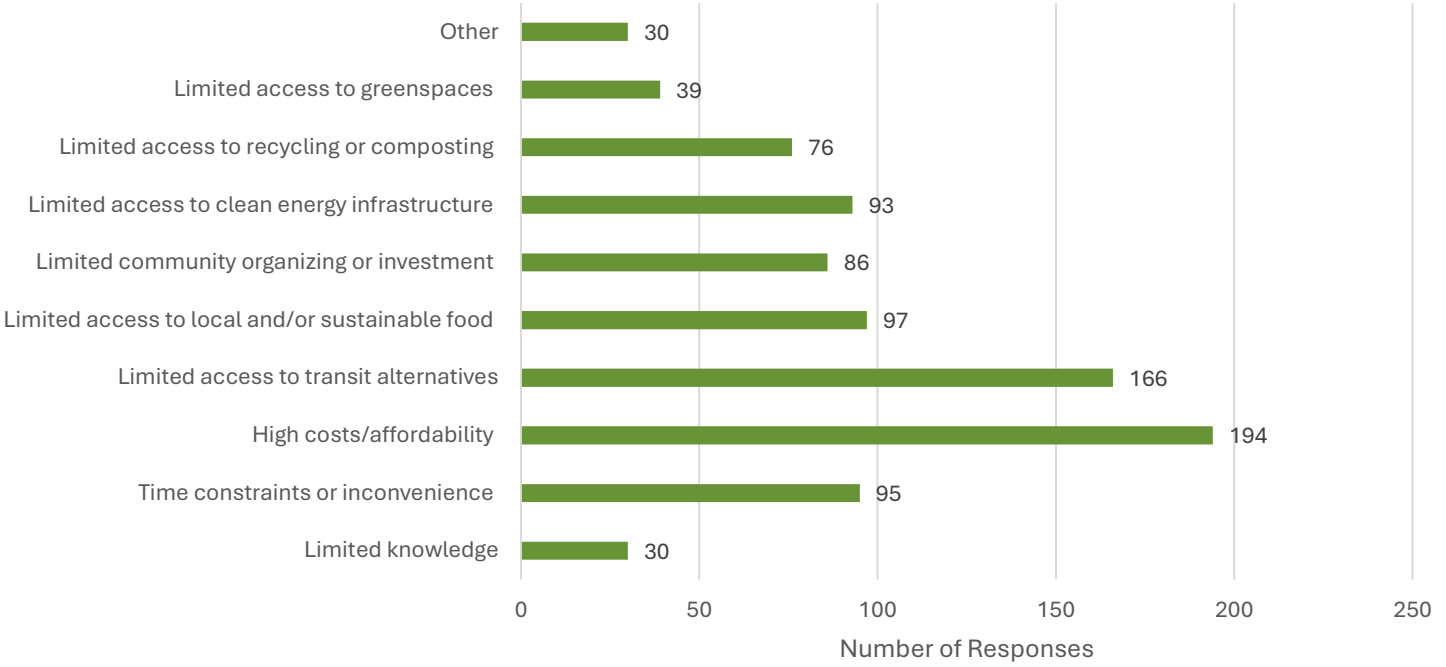


Figure D10: Survey I: What specific actions do you wish were in place in your community? Please select up to five choices

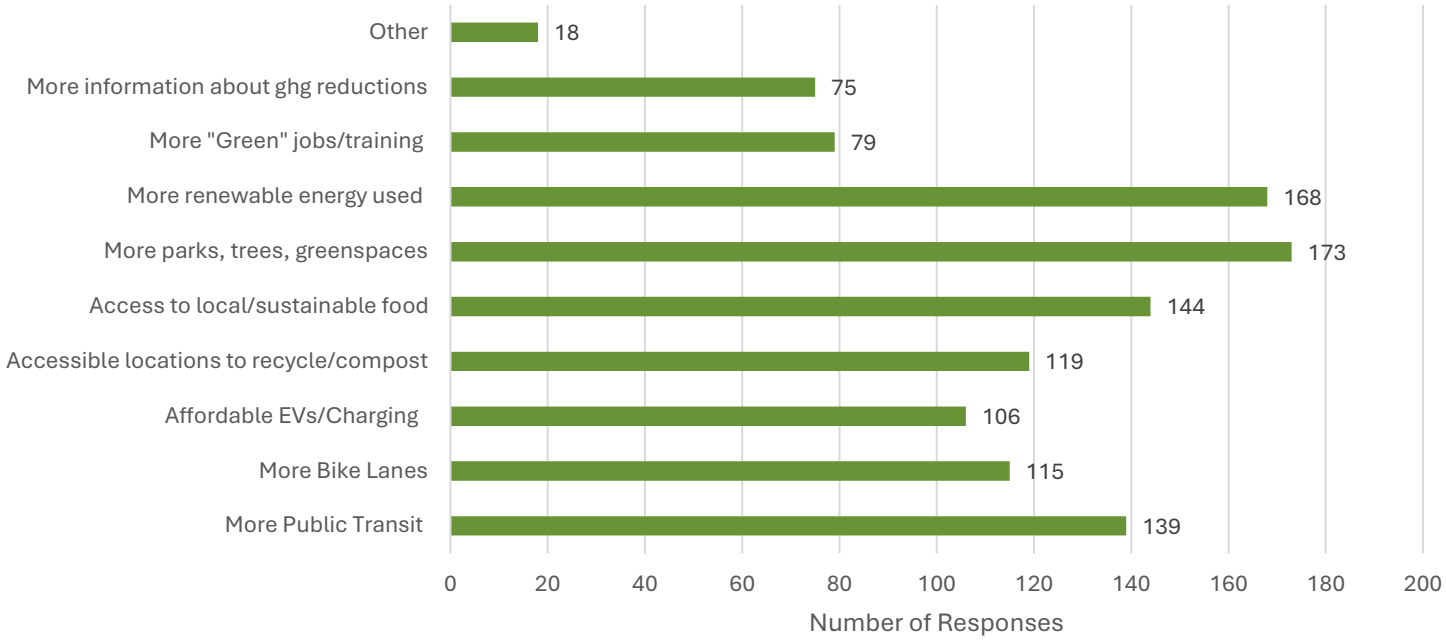


Figure D11: Survey I: What is the best way for you to receive information about the Climate Action Plan? Select all that apply

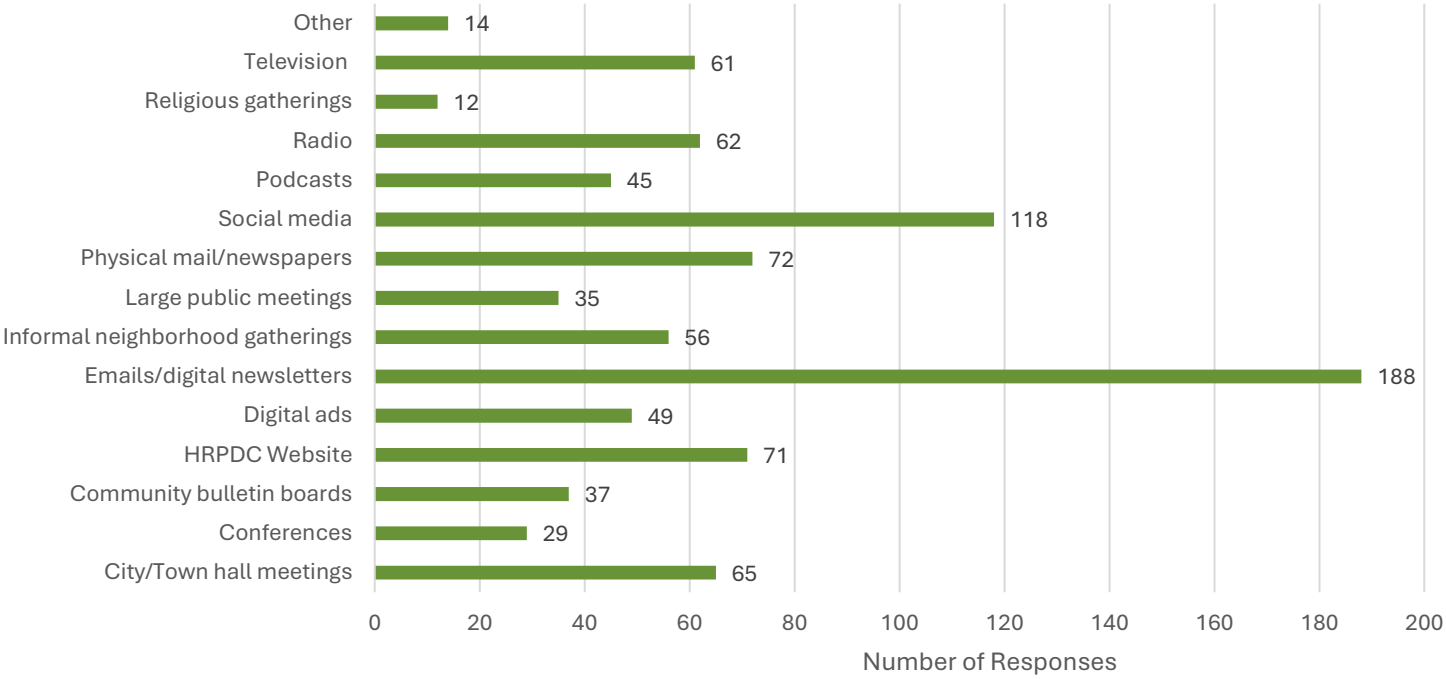


Figure D12: Survey I: Please select your county or city of residence from the options below

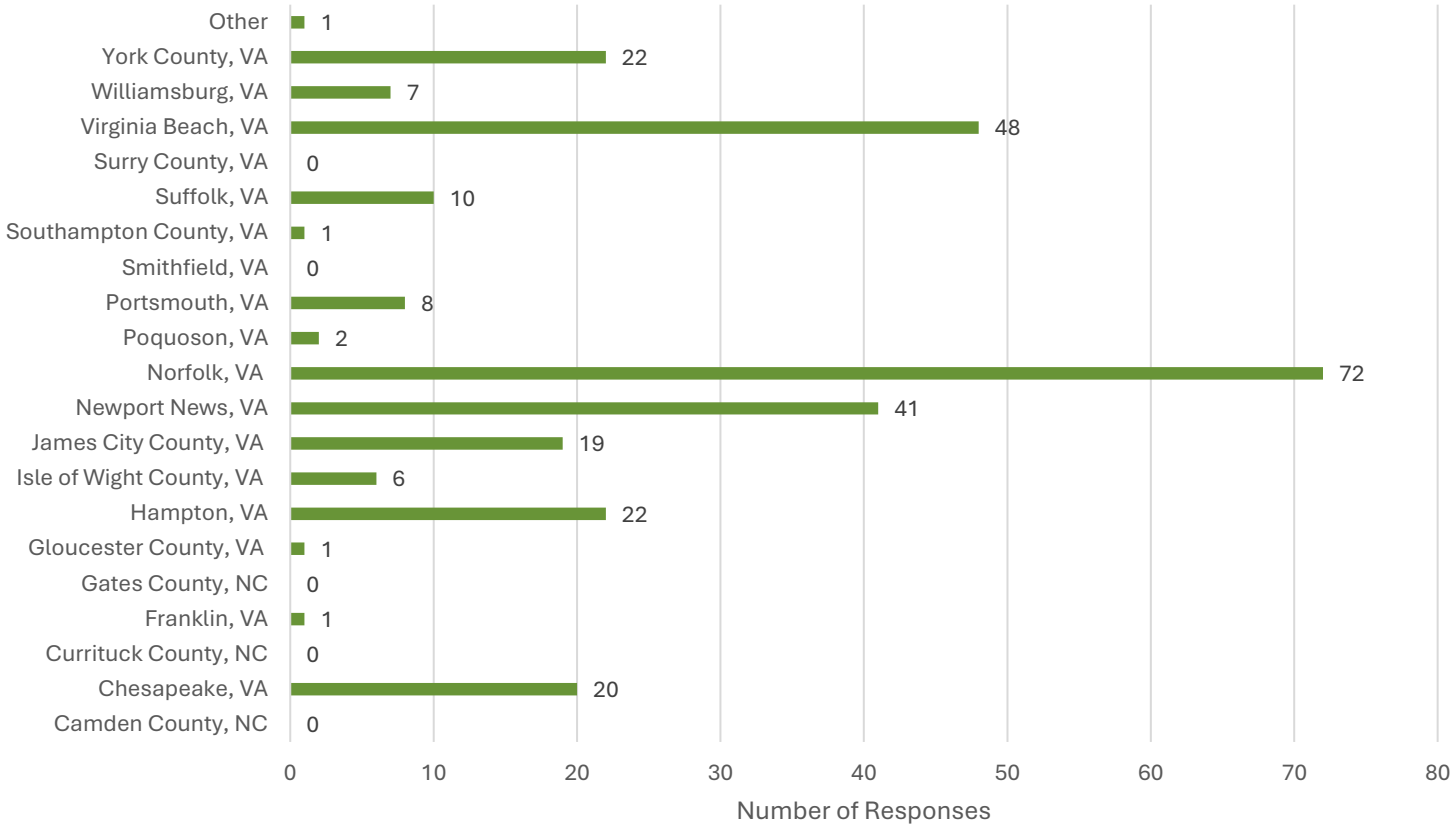


Figure D13: Survey I: What geographic area best describes where you live?

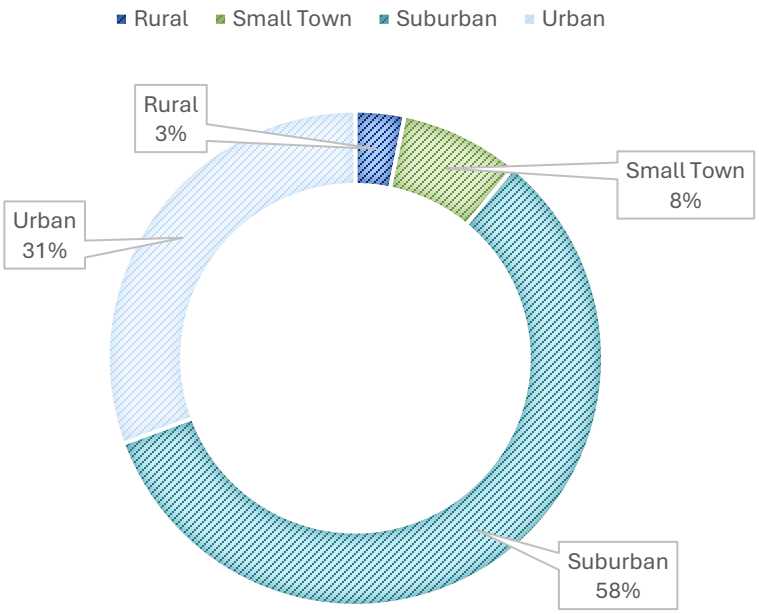
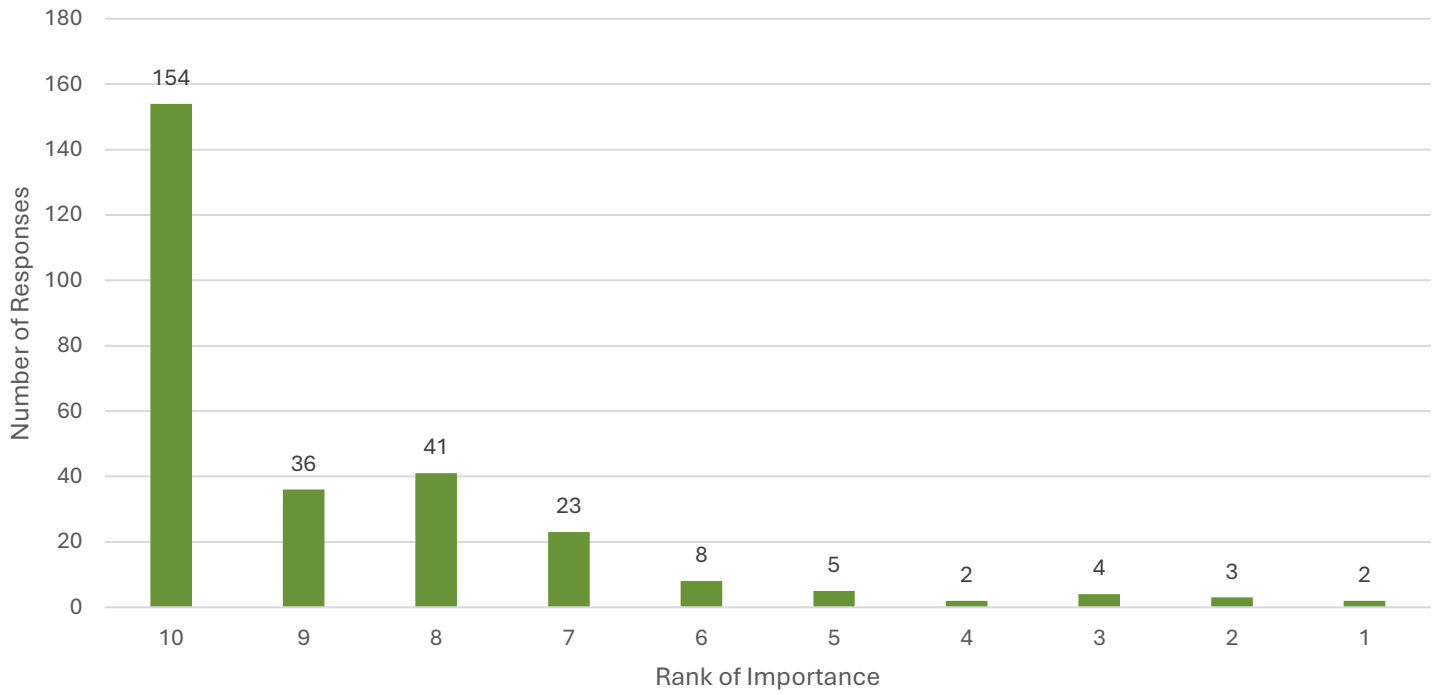


Figure D14: Survey I: How important is reducing greenhouse gas emissions to you? Select a value from 0 to 10, with 0 being 'Not important at all' and 10 being 'Extremely important'



Qualitative Feedback on Survey I

Overarching Themes from Public Feedback

The qualitative data analysis reveals several dominant themes that reflect the community's priorities for climate action. These themes provide a clear mandate for ambitious, specific, and equitable strategies.

1. Urgent Need for Transportation and Land Use Reform

The most prevalent theme was the urgent need to move away from the region's car-dependent transportation system. Respondents consistently expressed a desire to walk and bike more but felt it was fundamentally unsafe due to a lack of adequate infrastructure. There was a substantial public demand for investment in protected and separated bike lanes, continuous sidewalks, and a comprehensive public transit system that is frequent, reliable, and serves more locations.

> *"We need better bicycling infrastructure that actually goes where people want to go safely separated from car traffic... driving is the only option available to me for many of my daily trips."*

2. Protection and Enhancement of Natural Systems

A powerful sense of concern was expressed regarding the loss of natural spaces to development. Respondents view the protection of mature trees, the restoration of wetlands, and the preservation of green spaces and farmland as critical

climate mitigation and resilience strategies. There was strong support for policies that increase the urban tree canopy and halt the destruction of natural habitats for new roads and buildings.

> *"Trees! Stop the destruction in Chesapeake so much development. Roads and houses. They're tearing up the trees."*

3. Acceleration of the Clean Energy Transition

The community demonstrated a clear understanding of and support for a rapid transition to renewable energy. Feedback frequently highlighted the need to expand solar and wind generation, supported by electrical storage solutions. On a consumer level, respondents called for more public EV charging infrastructure and financial incentives to make EVs, hybrids, and home energy efficiency upgrades more affordable and accessible.

> *"Increased charging infrastructure for EVs would really be beneficial. Keep building out the wind and solar generation. Look into electrical storage... to put energy back into the grid when sun and wind are dormant."*

4. Demand for Effective Regional Collaboration

Respondents called for stronger and more effective collaborative planning among the region's localities. There is a desire for climate action plans that are decisively implemented rather than remaining as studies. The feedback highlights the importance of public education campaigns and sustained citizen engagement to ensure accountability and long-term success.

> *"Cities, please, please, work together as a region for not only this item, but for all sustainability, environmental, and economic initiatives. We can do so much more if we think beyond our city lines..."*

Unique and Novel Recommendations

Beyond the broad themes, respondents offered several specific and innovative suggestions that warrant consideration:

- **Institutional Emissions**: One respondent noted that a meaningful climate plan must address emissions from large institutions, specifically identifying the Department of Defense as a major consumer of petroleum in the region.
- **Digital and Information Equity**: A detailed response framed the lack of broadband access in non-urban parts of the region as a critical Environmental Justice (EJ) issue, arguing that inaccessibility to digital information prevents equitable participation in the planning process, particularly for aging populations.
- **Nuanced Environmental Solutions**: Multiple respondents advocated for nuanced solutions beyond simple energy efficiency, such as implementing "dark sky friendly" outdoor lighting with lower color temperatures to protect nocturnal wildlife.
- **Practical Consumer Support**: A highly practical suggestion was the creation of a need of reputable local contractors for services like solar panel and high-efficiency window installation, helping residents overcome barriers of trust and knowledge.

Dissenting Viewpoints

For a comprehensive representation of feedback, it is important to note that a minority of responses expressed skepticism or opposition to the premise of the survey and climate action planning. These comments generally characterized the effort as politically motivated or a misuse of public funds, with one respondent stating,

> *"I am tired of your fear mongering climate change propaganda."*

Conclusion

The public feedback received through the survey provides a clear and compelling direction for the Climate Pollution Reduction Grant plan. The community is not only concerned about climate change but also informed, offering specific, actionable, and sophisticated solutions. The dominant themes of transportation reform, natural space preservation, and clean energy transition will be highlighted in the CCAP.

Vehicle Miles Traveled (VMT) Survey

The VMT survey had 40 participants sourced from transportation technical committees at the HRTPO, including the HRTPO Active Transportation Subcommittee (ATS). Participants were asked to provide feedback related to reducing VMT to help reduce an individual's carbon footprint.

For this survey, the CCAP team used ArcGIS Survey123, an Esri product.

Demographics

The survey participants are primarily transportation technical professionals who aid in regional transportation and land use planning for Hampton Roads. They were identified and sought after for feedback based on their specific knowledge of active transportation, multi-modal transportation methods, and the resources required for implementation.

For a full breakdown of results, please see the attachments.

Results

Figure D15: VMT Survey - Q1: Please rank the proposed actions based on how impactful you anticipate them to be on reducing VMT

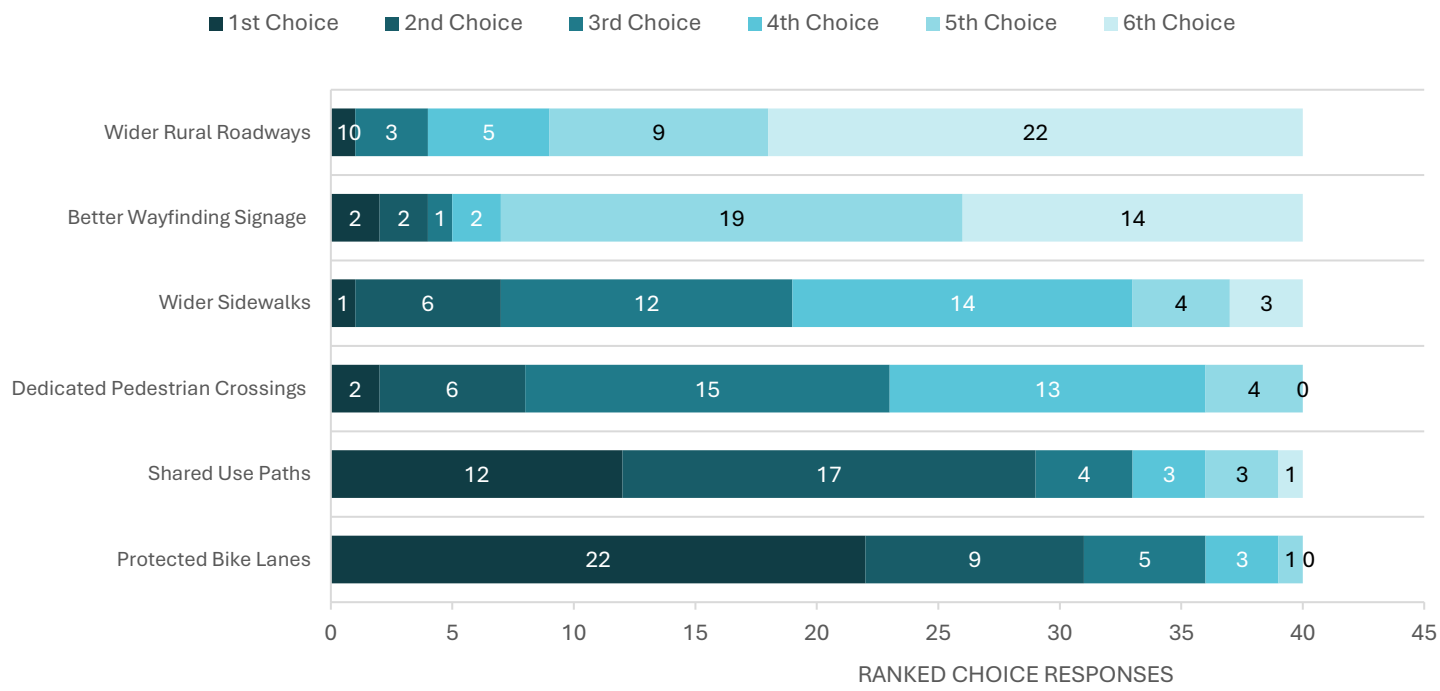
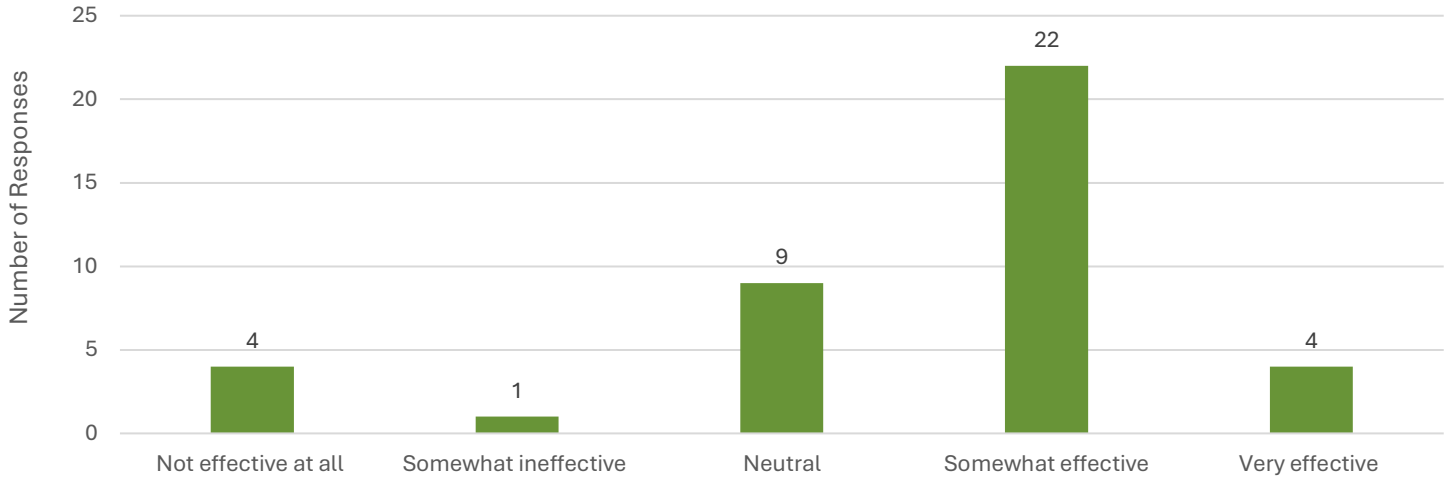


Figure D16: VMT Survey - Q2: Please share how impactful you think micromobility programs (bikeshare/scootershare, e.g. Pace, Lime, CitiBike) are in reducing VMT and promoting mode shifts



VMT Survey – Q3: Is there additional input that you'd like to provide related to reducing VMT or encouraging travel mode shifts? [Open-ended]

Key Themes from Respondent Feedback

1. **Infrastructure, Safety, and Connectivity.**

   The lack of safe and connected infrastructure for non-vehicular travel was a dominant theme.

   1.1. **Dedicated and Protected Spaces**: Respondents repeatedly called for "More protected bike lanes" and "dedicated space for micromobility and walkability programs." The need for these spaces to be "safe and separated from mobile traffic" was emphasized.

   1.2. **Context-Specific Design**: One professional noted that infrastructure choices are "very context specific," suggesting on-street bike lanes for local roads and off-street paths for faster-moving arterial roads.

   1.3. **Lack of Existing Facilities**: A major barrier is the current state of infrastructure in parts of the region, with one comment summarizing the issue bluntly: "You really can't get anywhere in Chesapeake without driving. No bike lanes, or wide sidewalks…". One commuter noted they would bike their "18 mile commute to work…if there were bike lanes from Chesapeake to Virginia Beach."

   1.4. **Convenience at Destinations**: Beyond paths and lanes, the need for end-of-trip facilities like "convenient bike parking at destinations" was highlighted as essential.

2. **Land Use and Proximity are Crucial**

   Several respondents argued that infrastructure alone is insufficient without addressing the region's sprawling land use patterns.

   2.1. **Zoning for Mixed Use**: One respondent stated that "Mixed use zoning is probably just as important as infrastructure." The rationale is that if essential destinations are too far, the quality of sidewalks or bike lanes becomes irrelevant.

   2.2. **Proximity is Key**: Another comment identified the "Proximity of residential areas to jobs and services" as a foundational element for reducing VMT. The sentiment was shared by another who noted that because "Hampton Roads is too spread out," micromobility is unlikely to have a significant impact on its own.

3. **Enhanced Public Transportation**

   Expanding and improving mass transit was seen as a critical component of a regional VMT reduction strategy

   3.1. **Light Rail Expansion**: A specific recommendation was to "extend the tide through south Norfolk and into Greenbrier." Another suggestion envisioned expanding the Tide Light Rail into a "full loop including all Hampton roads."

   3.2. **Bus Rapid Transit (BRT)**: The implementation of "Bus rapid transit" was also proposed as a solution.

   3.3. **General Improvement**: Some respondents simply called for "Better mass transit" as a necessary alternative to personal vehicle use.

4. **Policy, Funding, and Public Campaigns**

   Participants identified a need for stronger policy and dedicated funding to support the necessary changes.

   4.1. **Increased State and Regional Funding**: One professional asserted that "Raising the Department of Transportation (DOT) cost share toward more Bike/Ped related projects is a must on a state level and regional taxes."

   4.2. **Corporate Responsibility**: A suggestion was made that micromobility companies "can do more to support infrastructure costs and efforts" as demand grows.

   4.3. **Public Relations Campaign**: An idea was floated for a "PR campaign" to shift public perception and create a culture where drivers are more patient and expect to share the road with cyclists.

5. **Critiques and Practical Challenges**

   Respondents also pointed out current challenges and pragmatic considerations for implementation

   5.1. **Micromobility Obstructions**: The improper parking of scooters was identified as a nuisance, with one comment noting that they "can be trip hazards if they are randomly left in the road or on sidewalks."

   5.2. **Traffic Flow Concerns:** One participant expressed frustration with current traffic management, specifically suggesting to "get rid of the stick separator on I 64 so cars can move," believing it causes traffic jams and idling.

   5.3. **Geographic Diversity:** A key consideration for any regional plan is the diversity of land use, as "the city has 3 distinct areas (urban, suburban and rural, no one solution is possible."

Summary

This feedback underscores that reducing VMT in Hampton Roads requires a multifaceted approach. While the call for safer, connected infrastructure for biking and walking is a clear priority, professionals also emphasize that these investments must be paired with strategic land use reform, significant public transit expansion, and supportive regional funding policies. The responses collectively paint a picture of a region designed for automobiles, which will require deliberate and sustained effort across multiple sectors to transform into a place where alternative transportation is a safe, practical, and convenient choice for more residents.

Figure D17: VMT Survey - Q4: How important is it to conduct feasibility studies to ensure fair distribution of micromobility implementation (e.g. bike racks, reserved scooter parking, helmet subsidies, increased safety measures)?

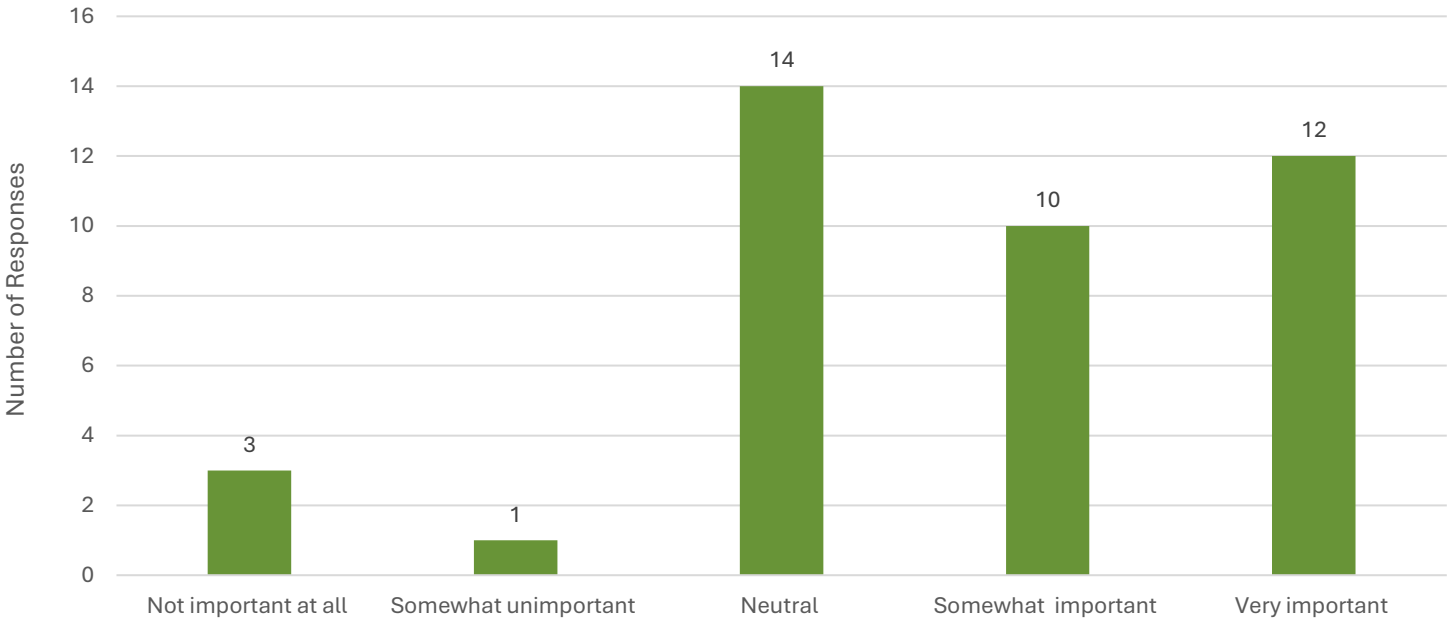
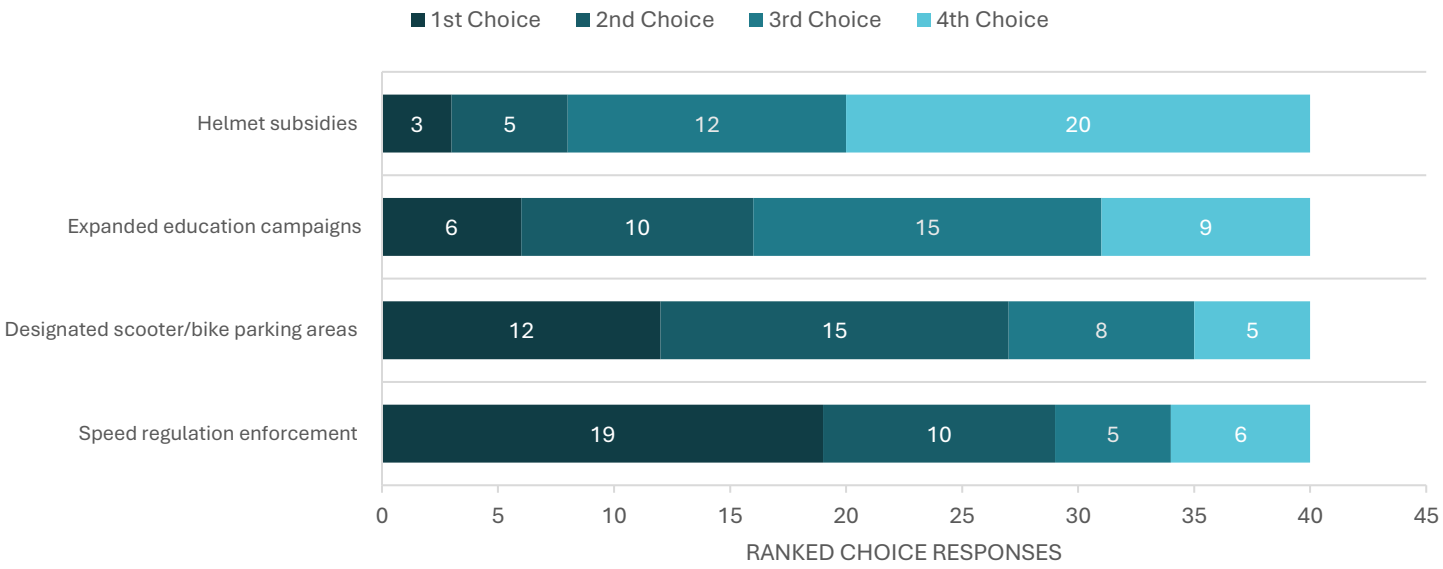


Figure D18: VMT Survey - Q5: Please prioritize the safety measures for micromobility users



VMT Survey – Q6: What strategies would encourage greater usage of micromobility? [Open-ended]

Challenges and Considerations

While there was broad support for these strategies, a critical perspective was also offered. One respondent noted, "These priorities aren't realistic for localities," highlighting potential financial or political barriers to implementing the necessary large-scale infrastructure projects. This suggests a clear and achievable implementation and funding strategy must accompany any proposed plan.

Summary

The feedback delivers a clear and consistent message: meaningful adoption of micromobility is contingent upon significant investment in safe, connected, and dedicated infrastructure. While incentives, education, and vehicle options are essential supporting elements, the core challenge lies in re-imagining and retrofitting the region's transportation corridors to accommodate all users safely. The success of micromobility programs is seen as being directly tied to the political will to fund and build these foundational networks.

Key Themes from Respondent Feedback

1. **Infrastructure for Safety and Connectivity is the Top Priority**

   This was the most frequently and passionately cited theme. Professionals believe that without a fundamental change to the built environment, micromobility will remain a niche option.

   a. **Dedicated and Protected Facilities**: The most common suggestions were for "protected bike lanes," "dedicated lanes," and "additional multi-use paths" to physically separate micromobility users from faster-moving vehicle traffic.
   b. **Network Connectivity**: Respondents emphasized that infrastructure must form a cohesive network. It needs to be practical for daily trips, connecting "residential areas to restaurants/parks/museums" and enabling users to "go to work/school/run errands without a car." The issue of a fragmented network with "very few intersections" was highlighted, as constant stopping is a significant deterrent.
   c. **Improved Road Design**: Suggestions went beyond bike lanes to include holistic street design changes, such as "wider sidewalks," "smaller curb radii," and "narrower streets." Specific problem areas, like creating safe paths for overpasses (e.g., Indian River Road, Greenbrier), were also mentioned.
   d. **Proactive Planning**: One professional noted that it would be "easier and less expensive to accomodate [micromobility] from the onset rather than trying to retro fit," pointing to the need for updated development patterns and codes.

2. **Traffic Enforcement and Driver Behavior**

   Directly linked to safety, participants expressed concern over the conflict between vehicles and micromobility users.

   a. **Speed enforcement**: Multiple responses called for "traffic speed enforcement" to calm vehicle speeds and create a safer environment for all road users. One participant stated plainly, "Drivers make it less safe."

3. **Policy, Incentives, and Funding**

   Professionals suggested several policy-level changes to both encourage micromobility and discourage personal vehicle use.

   a. **Financial Incentives**: Ideas included direct benefits for users, such as a "tax credit for miles travelled by bike for work" and "free use incentives" (e.g., "after 6 rides get 1 free").
   b. **Funding Mechanisms**: A "local gas tax to fund micro mobility infrastructure" was proposed as a dedicated funding source.

c. **Discouraging Vehicle Travel**: A direct approach was suggested, with one respondent noting that "discouraging vehicle travel is the most effective way to encourage micromobility."

4. **Integration with Public Transit**

Respondents saw micromobility not as a replacement for, but as a complement to, existing public transportation.

a. **First/Last Mile Solution**: Micromobility was identified as a key "last mile solution" that "needs to be paired with mass transit between city centers."
b. **Enhanced Access**: A specific recommendation was to provide "more access to Tide [light] Rail," allowing users to combine transit and micromobility for longer journeys.

5. **User Experience, Education, and Amenities**

Beyond infrastructure, the overall experience for the rider was a key consideration.

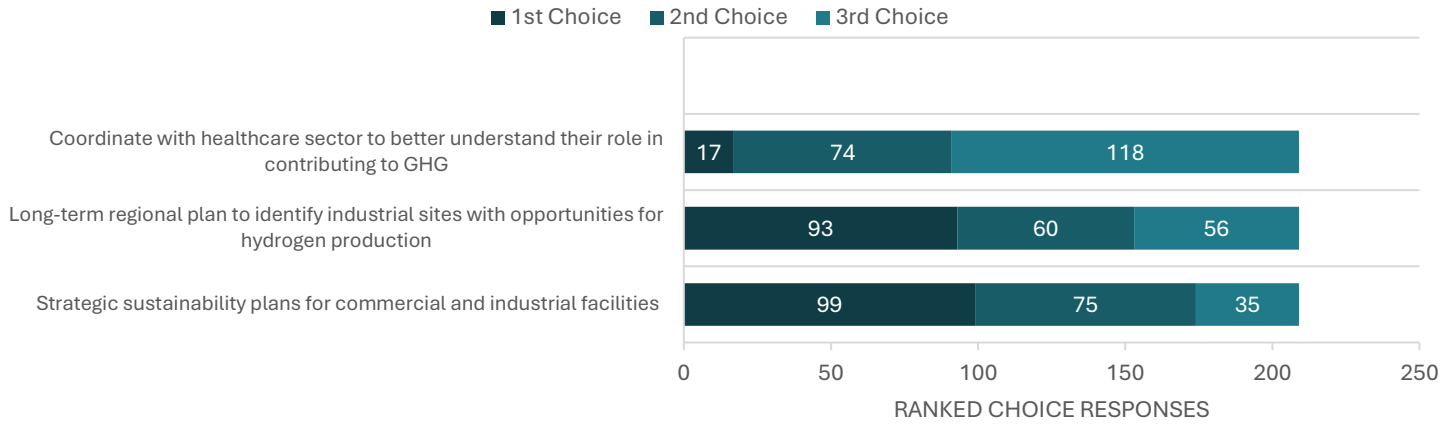
a. **Vehicle Diversity**: It was noted that the current scooter-dominant model may not serve all potential users. Providing options like "e-bikes or seated scooters" could attract "older less confident users."
b. **Amenities**: To make trips more comfortable, suggestions included "shady paths, rest/water & bike repair stations."
c. **Education and Clarity**: A need for "education campaigns" was identified, particularly regarding the rules of the road (e.g., "where you're supposed to ride them (on streets or on sidewalks…)").

Survey II

The second CCAP Survey had 216 respondents. This survey was created using proposed measures and actions based on the GHG inventory.Participants were asked to first prioritize proposed actions by sector and then asked to rank all of the proposed actions across sectors against one another.

The CCAP Engagement team used ArcGIS Survey123, an Esri product, for this survey.

Figure D19: Survey II - Q1: Industry Sector Measures. Please rank the following actions for each measure listed below in order of importance



Industry

- **Reducing Industrial/Commercial Emissions**: The highest-ranked action was to "Support the development of strategic sustainability plans for commercial and industrial facilities" (47.4%). This measure was closely followed by "Develop a long-term regional plan to identify industrial sites with opportunities for hydrogen production and/or use, carbon capture, electrification, use of other low-carbon fuels, or other reduction measures" (44.5%).

Figure D20: Survey II - Q2: Waste Sector Measures. Please rank the following actions for each measure listed below in order of importance

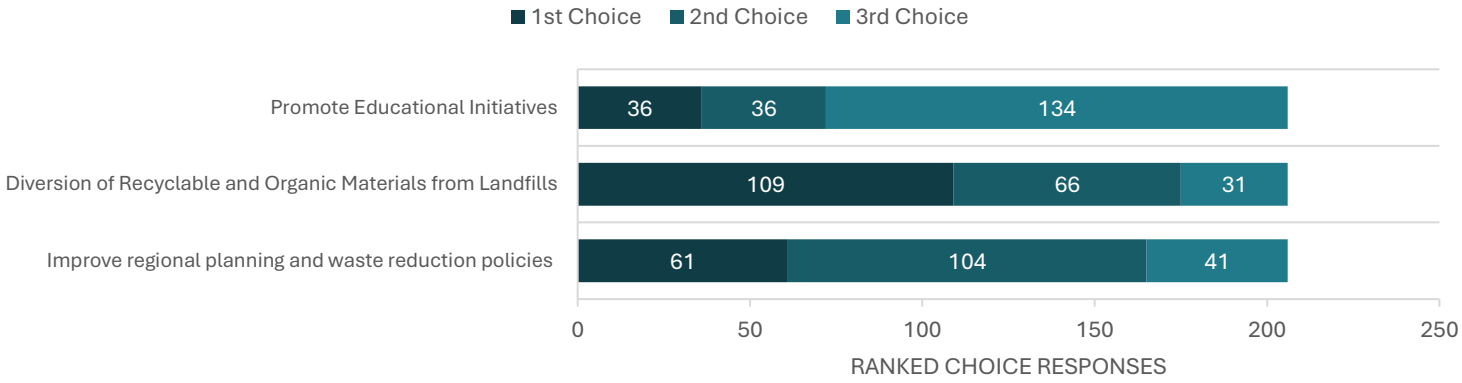
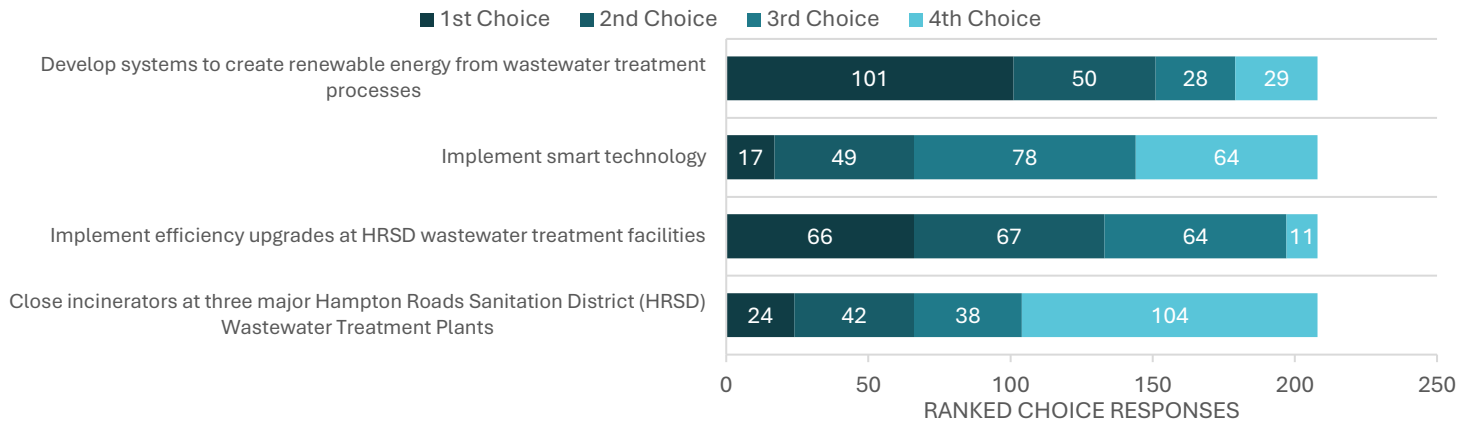


Figure D21: Survey II - Q3: Waste Sector Measures. Please rank the following actions for each measure listed below in order of importance



Waste Management

Respondents prioritized diverting waste and creating renewable energy from waste streams.

- **Landfills:** The top-ranked action was the "Diversion of Recyclable and Organic Materials from Landfills" (52.9%).
- **Wastewater Treatment Plants:** The leading priority was to "Develop systems to create renewable energy from wastewater treatment processes" (48.6%).

Figure D22: Survey II-Q4: Agriculture & Forestry Sector Measures. Please rank the following actions for each measure listed below in order of importance

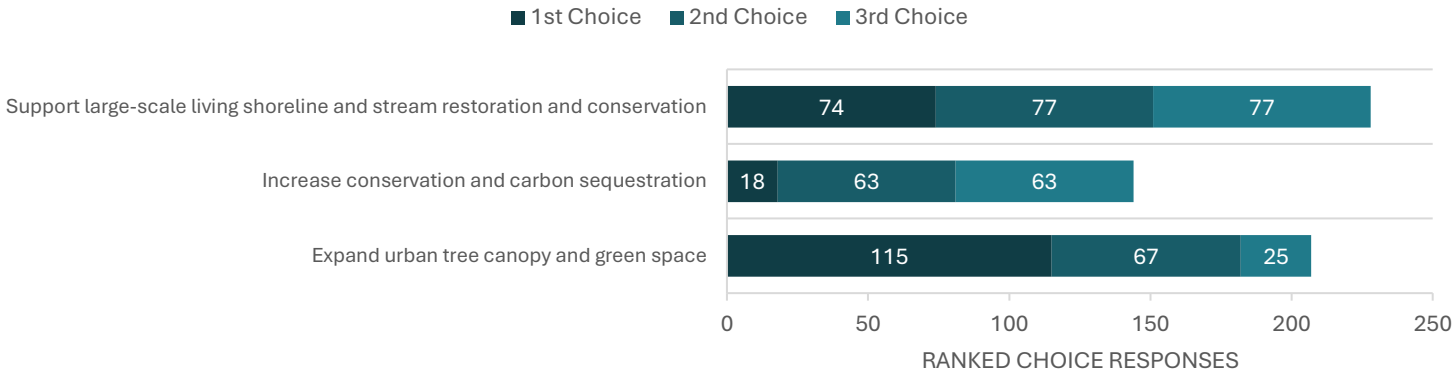


Figure D23: Survey II-Q5: Agriculture & Forestry Sector Measures. Please rank the following actions for each measure listed below in order of importance

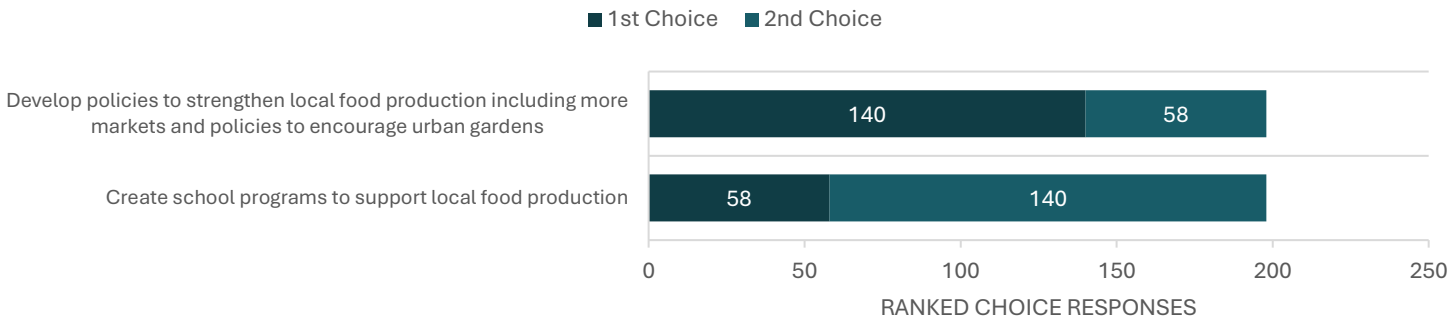
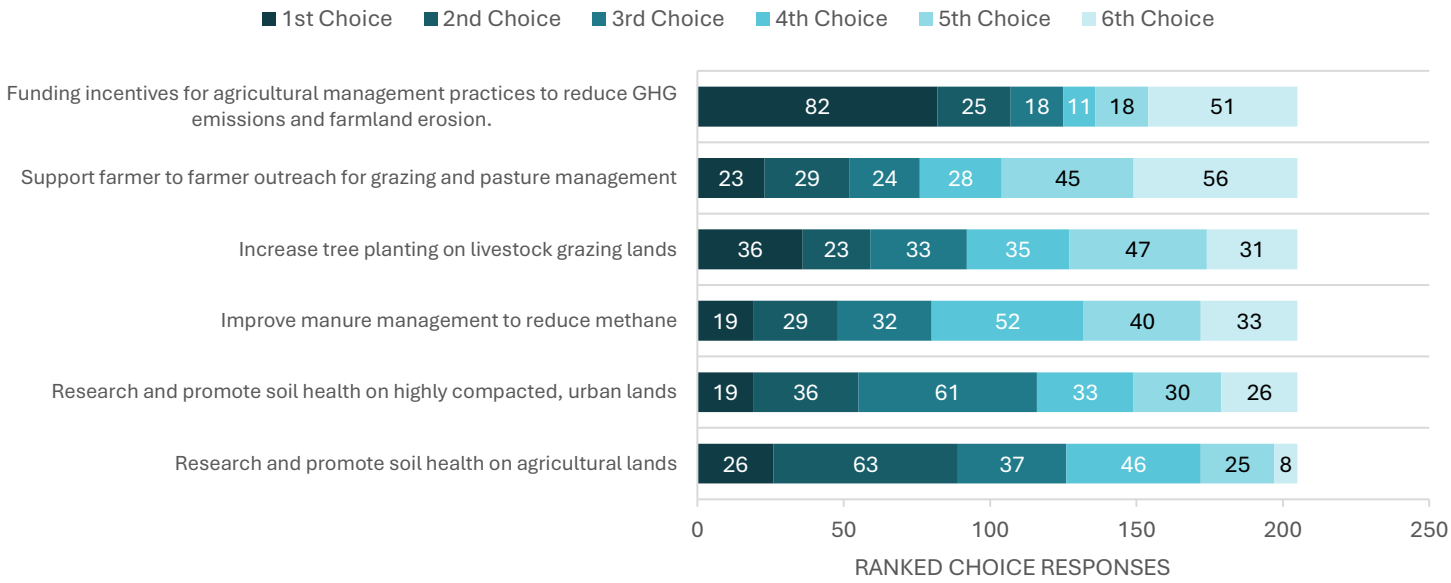


Figure D24: Survey II-Q6: Agriculture & Forestry Sector Measures. Please rank the following actions for each measure listed below in order of importance



Agriculture & Forestry

This sector also saw high levels of agreement on top priorities, focusing on local food systems and natural resources.

- **Carbon Sequestration**: The top priority was to "Expand urban tree canopy and green space" (55.6%). It should be noted that this measure was also one of the top-ranked measures overall in question 15, where participants were asked to rank all measures against one another.
- **Local Food Production & Urban Agriculture**: The highest-ranked action, with 70.7% of respondents ranking it first, was to "Develop policies to strengthen local food production, including more markets and policies to encourage urban gardens."
- **Soil Conservation**: Respondents prioritized "Funding incentives for agricultural management practices to reduce greenhouse gas emissions and farmland erosion" (53.2%).

Figure D25: Survey II-Q7: Transportation Sector Measures. Please rank the following actions for each measure listed below in order of importance

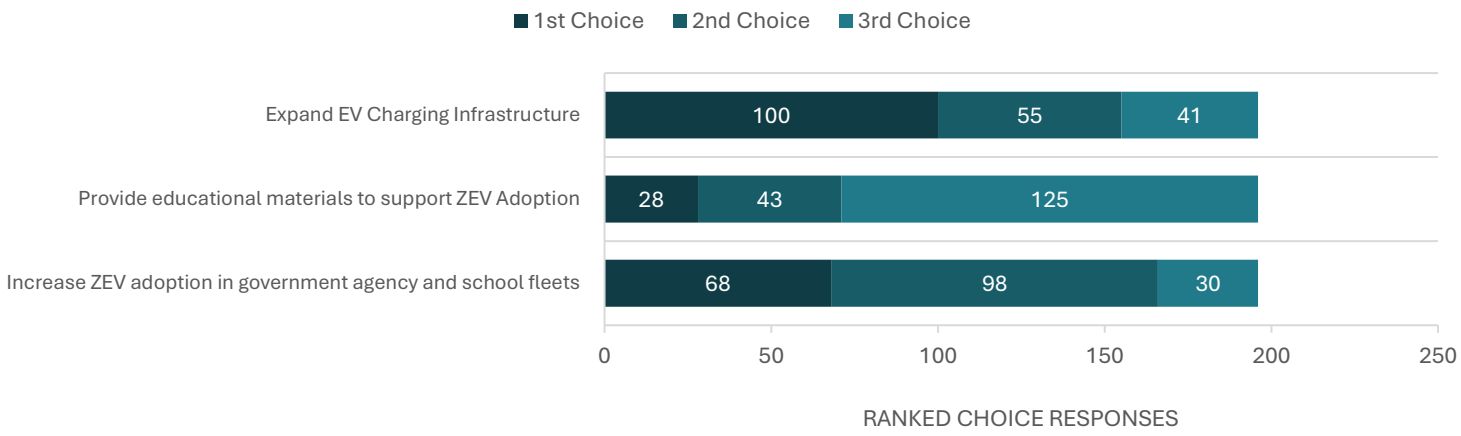


Figure D26: Survey II-Q8: Transportation Sector Measures. Please rank the following actions for each measure listed below in order of importance

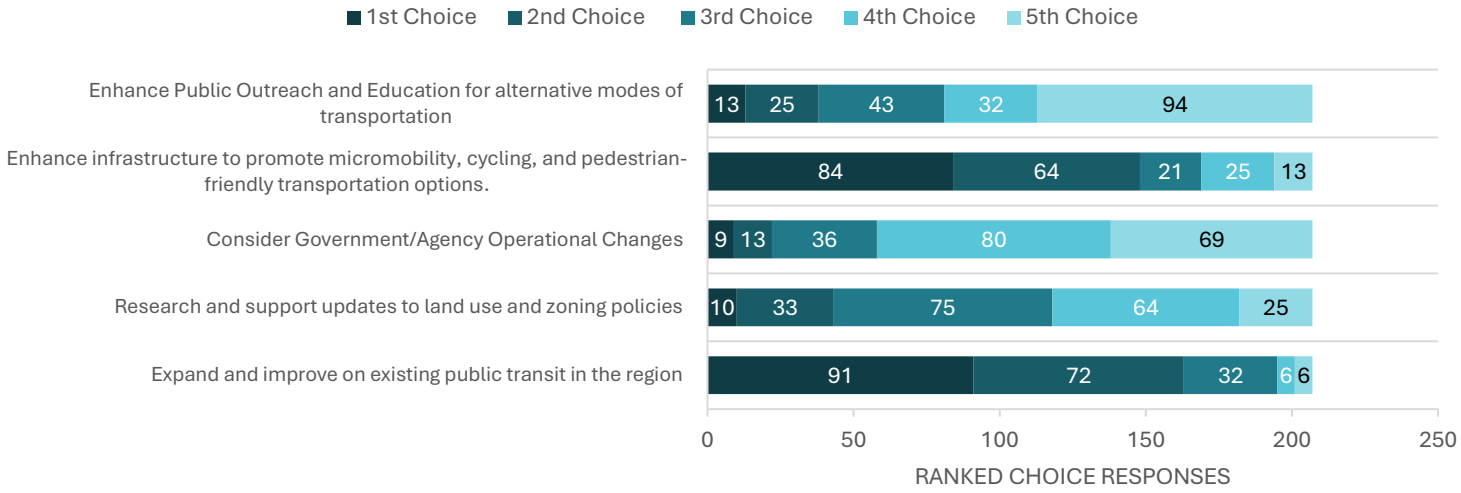
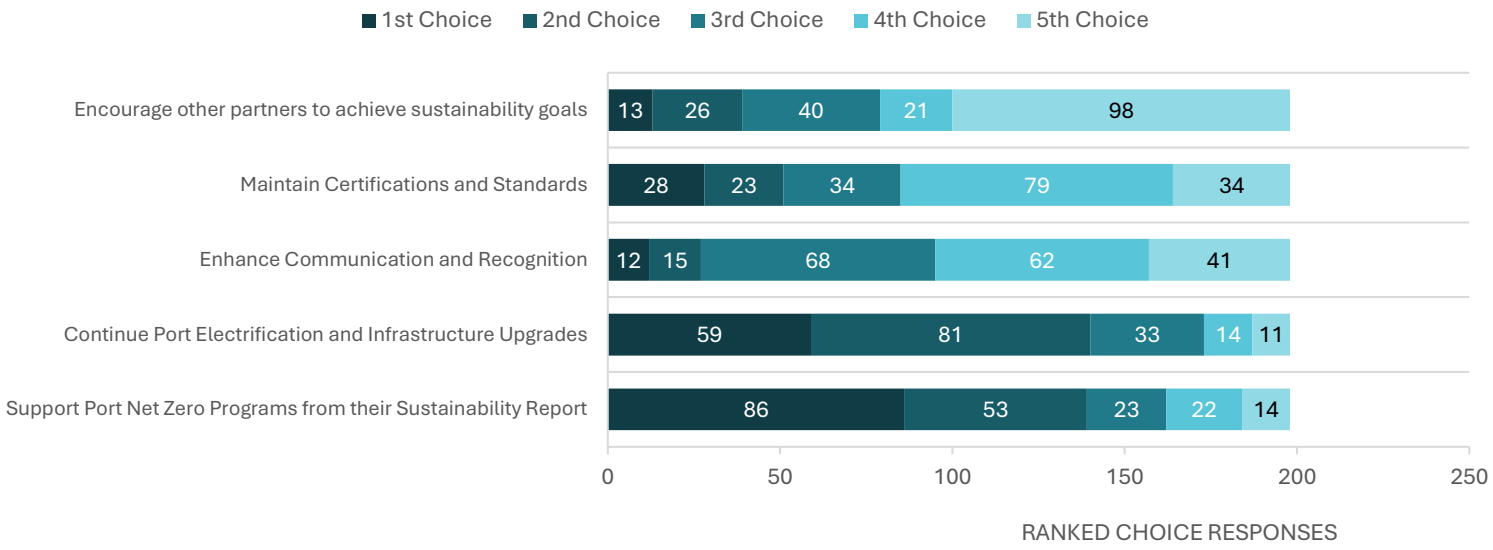


Figure D27: Survey II-Q9: Transportation Sector Measures. Please rank the following actions for each measure listed below in order of importance



Transportation

Priorities in the transportation sector focused on infrastructure for alternative fuels and modes of transit, as well as improving public transit.

- **Zero-Emission Vehicles (ZEVs)**: The clear top action was to "Expand EV Charging Infrastructure," which 51.0% of respondents ranked as most important.
- **VMT Reduction**: The leading strategy was to "Expand and improve on existing public transit in the region" (44.0%).
- **Freight**: The top-ranked action was "Support Port Net Zero Programs from their Sustainability Report" (43.4%). With freight being one of the major economic drivers for Hampton Roads and Virginia, supporting sustainable initiatives is vital to reaching carbon emissions reduction goals.

Figure D28: Survey II-Q10: Buildings Sector Measures. Please rank the following actions for each measure listed below in order of importance

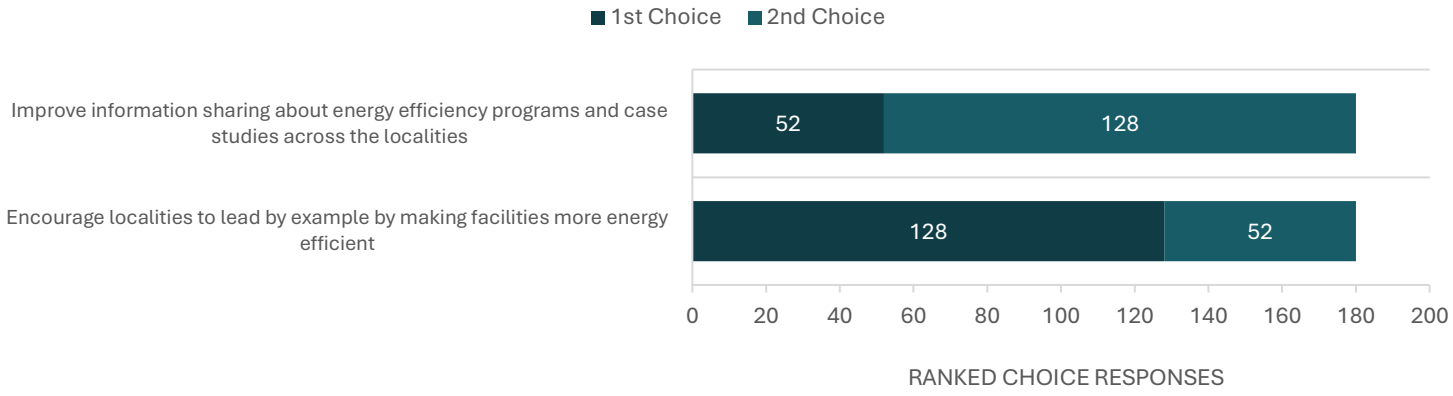


Figure D29: Survey II-Q11: Buildings Sector Measures. Please rank the following actions for each measure listed below in order of importance

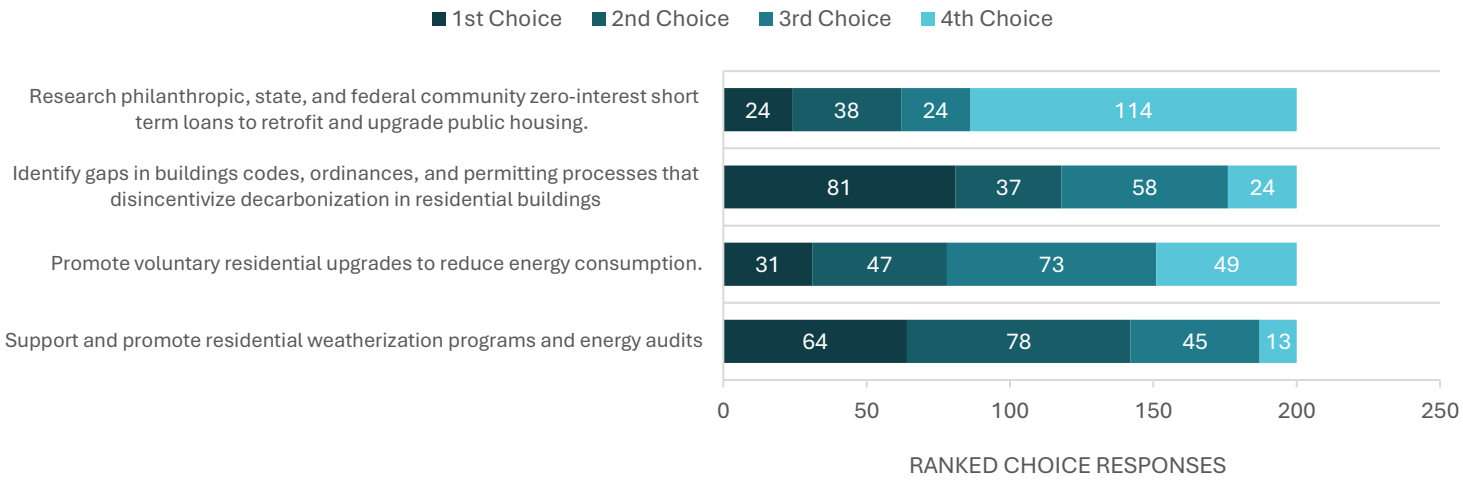
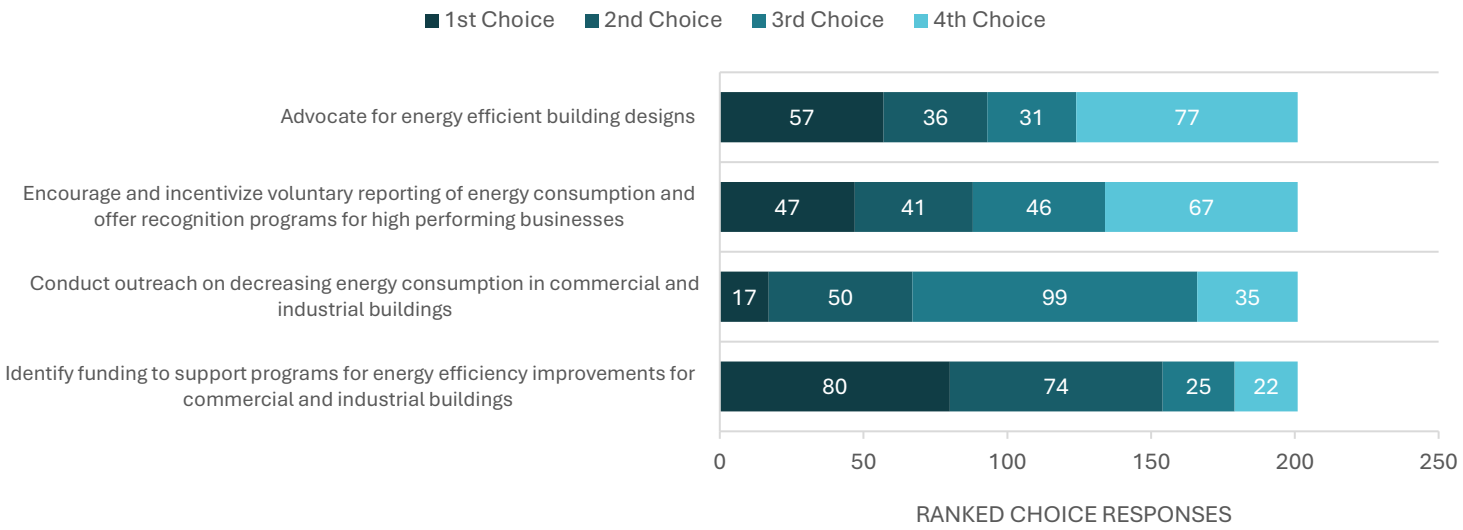


Figure D30: Survey II-Q12: Buildings Sector Measures. Please rank the following actions for each measure listed below in order of importance



Buildings

Building sector actions received some of the strongest consensus among all categories.

- **Existing Municipal Buildings**: The top priority was to "Encourage localities to lead by example by making facilities more energy efficient," with a strong majority of 71.1% of respondents ranking this as most important.
- **Existing Residential Buildings**: The leading action was to "Identify gaps in building codes, ordinances, and permitting processes that disincentivize decarbonization in residential buildings" (40.5%).
- **Existing Commercial Buildings**: Respondents prioritized to "Identify funding to support programs for energy efficiency improvements for commercial and industrial buildings" (39.8%).

Figure D31: Q13: Energy Sector Measures. Please rank the following actions for each measure listed below in order of importance

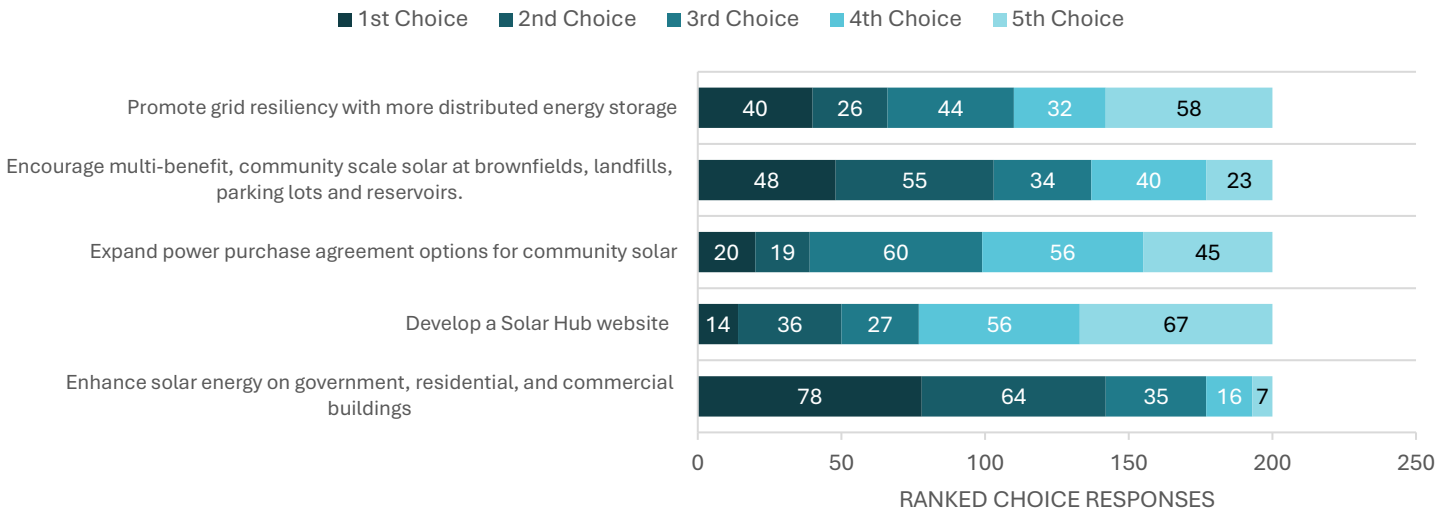
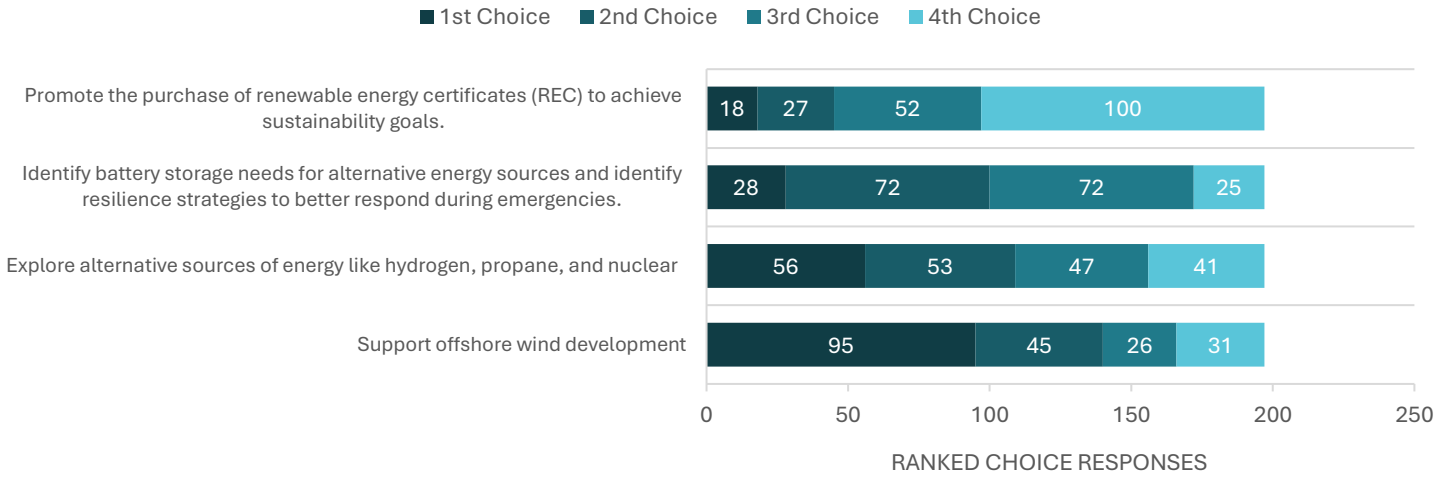


Figure D32: Q14: Energy Sector Measures. Please rank the following actions for each measure listed below in order of importance

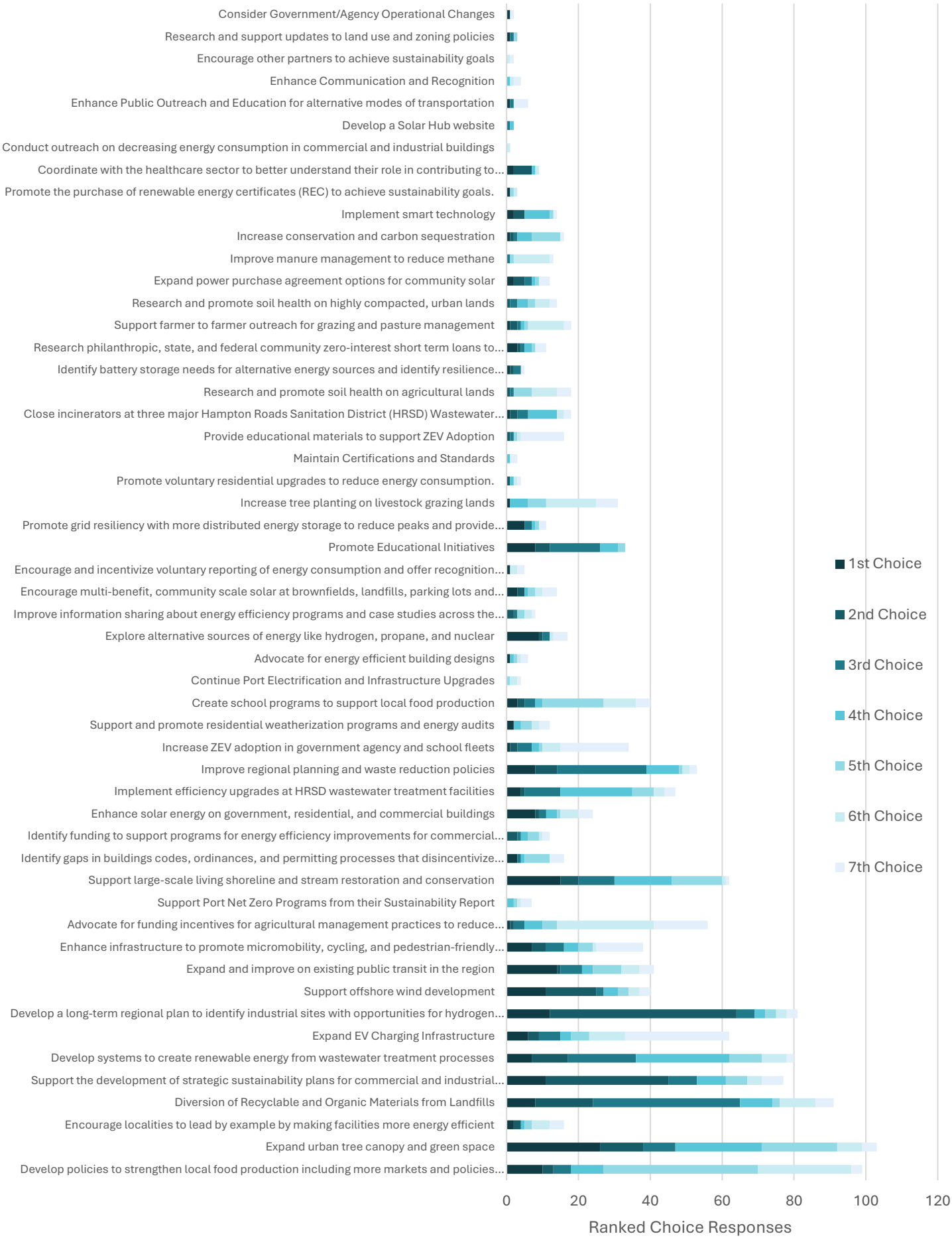


Energy

In the energy sector, respondents prioritized enhancing solar energy in existing buildings over other renewable options. For grid modernization, most participants favored exploring alternative energy sources like hydrogen and nuclear over improving grid resiliency and storage.

- The action to "**Enhance solar energy on government, residential, and commercial buildings**" was the clear top priority, receiving the most first-choice votes (43%). Community-scale solar was a strong second choice (37.8%). Supporting offshore wind development was ranked as the lowest priority of the three, receiving the fewest first-choice votes and the most third-choice votes (19.2%).
- **Exploring alternative energy sources like hydrogen and nuclear** was the highest-priority action by a significant margin, earning 104 first-choice votes (53.9%). Promoting grid resiliency with distributed energy storage was the second priority (30.1%), although it received more second-choice votes than first-choice votes. Identifying battery storage needs was the lowest-ranked action, receiving the fewest first-choice votes (16.1%) and the most third-choice votes.

Figure D33: Overall Measure Rankings



Overall Top Priority

Participants were asked to provide an overall ranking for all the proposed measures in the six sectors they had ranked separately in the preceding questions.

Across all sectors, the top-ranked single measure was "**Expand urban tree canopy and green space**" from the Agriculture & Forestry sector, with 26 first-choice rankings.

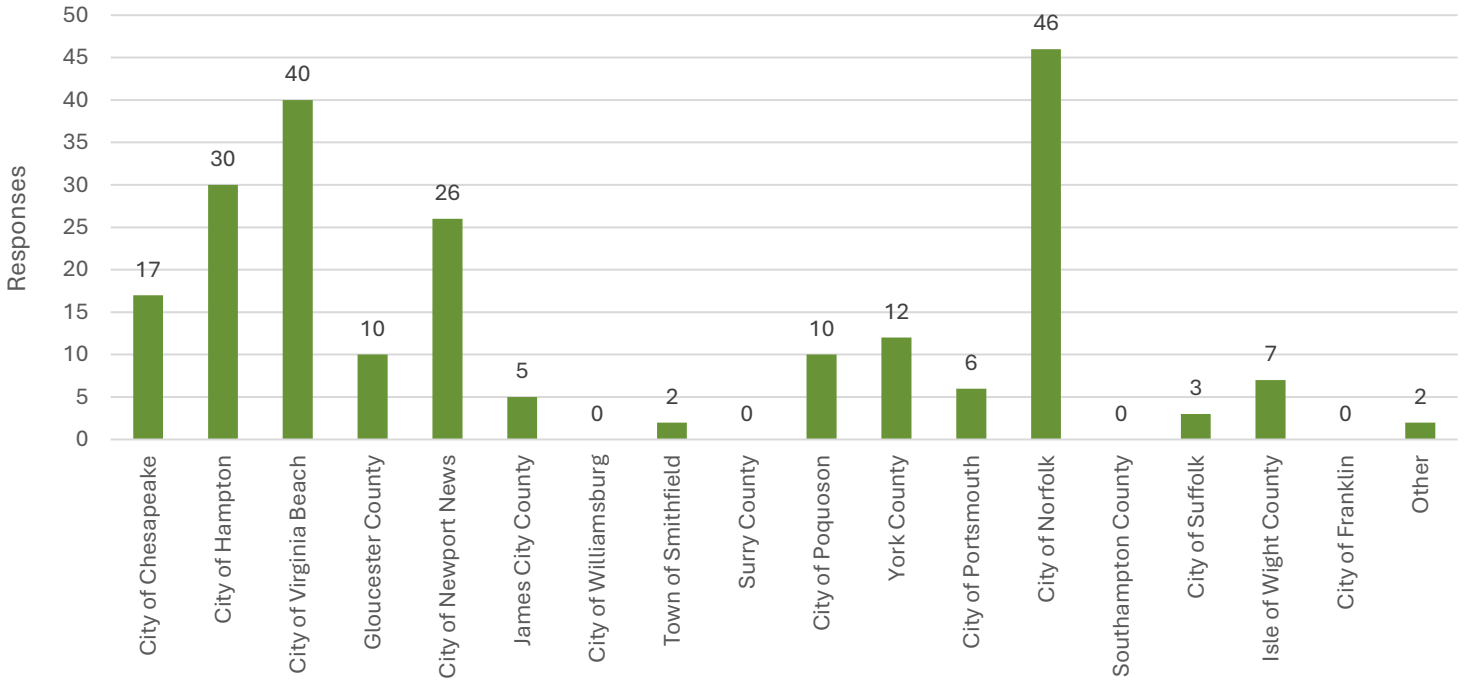
This suggests that expanding green spaces is the highest-priority action item among all proposed measures for survey participants.

Top Priorities by Sector

When analyzing the top priority within each individual sector, the following measures were ranked highest:

- **Agriculture & Forestry**: The clear favorite was "Expand urban tree canopy and green space" with 26 first-choice rankings.
- **Transportation**: The top priority was to "Expand and improve on existing public transit in the region," which received 14 first-choice rankings.
- **Industry**: The leading measure was to "Develop a long-term regional plan to identify industrial sites with opportunities for hydrogen production and/or use, carbon capture, electrification, use of other low-carbon fuels, or other reduction measures," with 12 first-choice rankings.
- **Energy**: The highest-ranked measure was to "Support offshore wind development," receiving 11 first-choice rankings.
- **Waste**: The top choice was the "Diversion of Recyclable and Organic Materials from Landfills," which garnered 8 first-choice rankings.
- **Buildings**: The highest-ranked priority was to "Identify gaps in buildings codes, ordinances, and permitting processes that disincentivize decarbonization in residential buildings," with 3 first-choice rankings.

Figure D34: Respondents by locality for Survey II



Summary of Additional Survey Comments

The open-ended feedback provided a wide range of commentary, which fell into three main categories: critiques of the survey's technical functionality and design, recurring themes and parallels in policy priorities, and novel suggestions for climate action.

1. **Feedback on the Survey Instrument**

   A significant portion of the feedback focused on the survey design, highlighting technical issues and perceived biases.

   1.1. **Technical Usability Issues:** This was the most frequent topicin the feedback. Numerous participants reported being unable to complete the final drag-and-drop ranking question, especially on mobile devices (iPhone, iPad Safari) but also on laptops.

      1.1.1. Note: When survey administrators became aware of this problem, an open-ended question was added to allow participants to enter their rankings manually. Considering this issue, it is unlikely that this format will be utilized with ArcGIS Survey123 again.

   1.2. **Survey Design and Bias**: Several respondents critiqued the survey's design, calling the questions “leading” and “one-sided.” They felt the format did not allow for disagreement with the proposed initiatives or for offering alternative responses, with one person stating the options did not “fit your agenda.”

2. **Parallels in Policy Feedback**

   Beyond the survey's mechanics, several policy themes emerged repeatedly, indicating strong areas of public concern and consensus.

   2.1. **Land Use and Greenspace**: This was a dominant theme. Commenters frequently advocated for protecting natural spaces, stopping the use of undeveloped land for new housing, removing vacant buildings and parking lots to create parks, and protecting the existing tree canopy. There was strong support for “dense walkable city centers” and policing “greedy developers.”

      2.1.1. Note: Creating and protecting green spaces received significant support from respondents.

   2.2. **Expansion of Public Transportation**: Many participants called for “better public transportation,” with specific and repeated requests to expand the Tide light rail to other areas of Hampton Roads and into Virginia Beach.

      2.2.1. Note: An attempt to extend the Tide light rail into Virginia Beach previously failed due to a local referendum that opposed the extension.

   2.3. **Critique, Skepticism, and Alternative Priorities**: A minority sentiment was that the climate plan was a misuse of taxpayer money. These respondents urged the city to focus on other priorities like “fighting crime” and fixing basic infrastructure (“city streets collapsing,” “clean the storm drains”). Some dismissed climate change as a “fraud” or “scientifically unproven assertion.”

   2.4. **Specific Technology Preferences**: Participants expressed strong and often conflicting opinions on energy technology. There was clear opposition to solar farms (with a preference for rooftop solar), offshore wind, and nuclear energy (with one user citing flood vulnerability of Small Modular Reactors). Conversely, there were also calls for “investment in all clean energy solutions.”

3. **Novel Feedback and Specific Suggestions**

   Several comments provided unique, actionable ideas that were not otherwise mentioned.

   3.1. **New Programs and Policies**: Suggestions included implementing a “pay-as-you-throw” waste incentive system, creating a “Green Business Alliance” modeled after Charlottesville's, and developing a regional panel of citizen environmental leaders.

   3.2. **Specific Projects**: Commenters proposed a pilot project to recycle glass for environmental restoration, reopening a waste-to-energy plant (Wheelabrator), and exploring hydrokinetic energy from moving water.

3.3. **Public Education**: One novel idea was to run a public education campaign to build appreciation for local wetlands, such as a “rename the swamp” contest**.**

In summary, the additional comments provided valuable insight. They highlighted critical usability issues with the survey that may have impacted the data, while also revealing strong community consensus around improving public transit and prioritizing green spaces and more innovative land use. Finally, the feedback offers several novel, community-sourced ideas for inclusion in the climate action plan.

Engagement Activities

Rally for our Climate Future

Details: April 17, 2025, 5:00 PM – 6:00 PM at Mount Trashmore, 310 Edwin Dr., Virginia Beach, VA 23462

Engagements: 65 people

The Virginia League of Conservation Voters, Climate Action Virginia, Chesapeake Climate Action Network, and Sierra Club Virginia Chapter hosted the Rally for our Climate Future to celebrate the climate investments that have benefited the Hampton Roads Region and advocate for continued investments.

The CCAP Engagement team connected with about 65 members of the public and encouraged attendees to provide their input on the Climate Action Plan by leaving public comment in person, email, or on the Climate Action Plan's website (www.hrpdcva.gov/climate)

Figure D35: Rally For Our Climate event. Table set up

“Our Power, Our Planet” Hampton City Earth Day Celebration

Details: April 26, 2025, 10:00 AM – 2:00 PM at Blue Bird Gap Farm 60 Pine Chapel Road, Hampton, VA 23666

Engagements: 32 people

The City of Hampton held its annual Earth Day event at Blue Bird Gap Farm and hosted the Environmental Festival & Eco-Art Show. The CCAP Engagement team informed people about the Climate Action Plan and asked that they remain engaged throughout the process.

Figure D36: Our Planet, Our Power Event. Connecting with community members

Figure D37: Our Planet, Our Power Event. Table set up

Cap2Cap

Details: May 9, 2025, 9:00 AM – 5:00 PM at Chickahominy Riverfront Park, 1350 John Tyler Hwy, Williamsburg, VA, 23185. K

Engagements: 100 People

Cap2Cap is the Virginia Capital Trail Foundation's annual bike ride fundraiser. Attendees ride the bike trail from Richmond to James City County and raise funds for the maintenance and expansion of the trail system. The CCAP Engagement team connected with about 100 members of the public and introduced them to the Climate Action Plan.

A key discussion point during this outreach was Trail757, the proposed route, expansion, and related funding. Many people expressed support for protecting and maintaining green spaces and multimodal options like trails.

Figure D38: Cap2Cap event. Interacting with community members

CNU Earth Day

Details: April 26, 2025

Engagements: Approximately 100

The CCAP Engagement team participated in CNU's Annual Sustainability event for Earth Day 2025. At the event the team informed and engaged students about the creation of the Climate Action Plan and encouraged them to engage with the process.

Figure D39: CNU Earth Day Event. CCAP Project Lead, Whitney Katchmark, interacting with students

Norfolk LIVE Green

Details: May 3, 2025, 11:00 AM – 2:00 PM, 3500 Granby St, Norfolk, VA 23504

Engagements: 108

The CCAP Engagement team participated in Norfolk's annual Earth Day event, LIVE Green Norfolk which encourages the public to think and live sustainably. The team informed and engaged the public about the Climate Action Plan and encouraged them to get involved.

Figure D40: Norfolk LIVE Green event, HRPDC/TPO Executive Director Bob Crum featured with Norfolk City Councilman Jeremy McGee

Pride in the ’Peake

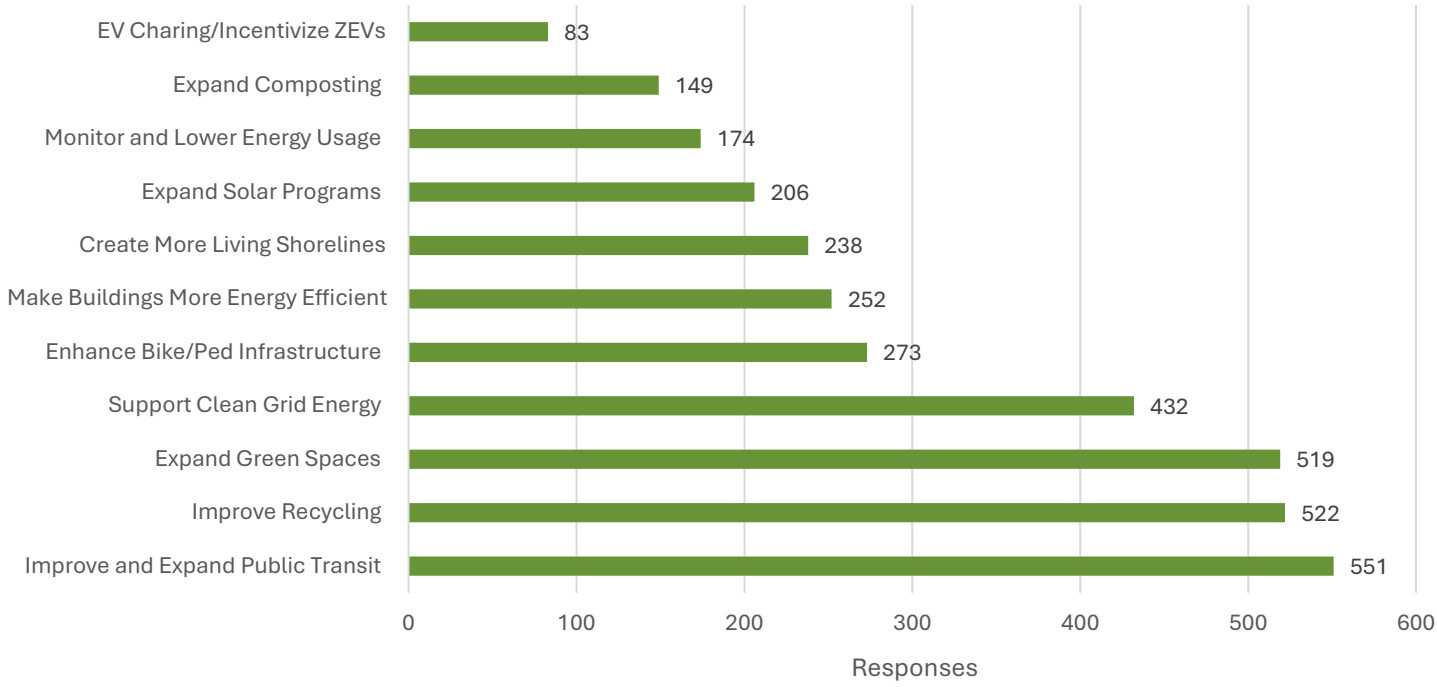
Details: June 22, 2025, 10:00 AM – 5:00 PM, at Chesapeake City Park, 900 City Park Dr., Chesapeake, VA 23320

Engagements: 245

Pride in the Peake’ is Chesapeake’s annual Pride event. Community members were briefed on the CPRG Planning Grant and then asked to determine investments given “Climate Cash” in $10, $5, and $1 denominations totaling $16 in *Climate Cash* per person. Participants were able to choose from 12 high-level, summarized actions.

- Improve Recycling Programs
- Expand Composting
- Expand Green Spaces
- Create More Living Shorelines
- Expand EV Charging Network
  - Incentivize ZEVs (later combined)
- Improve and Expand Public Transit
- Enhance Bike/Ped Infrastructure
- Monitor and Lower Energy Usage
- Make Buildings More Energy Efficient
- Expand Solar Programs
- Support Clean Grid Energy
  - Based on the feedback from participants, the results below were received.

Figure D41: Pride in the 'Peake Climate Cash Activity



Event Highlights

Public Transit

While engaging with community members, several referenced the importance and need to properly invest in public transit. Many referred to other regions they lived in that allowed for easier, more reliable, and more efficient use of public transit, allowing them to reduce their individual carbon footprints naturally.

Some described that while they do not live too far away from their localities' urban center, the lack of public transit to the more suburban or less urban areas was significantly lacking, and some of the transit offered was unsafe to access from where they live.

A conversational throughline for most community members was that they wished they had more access to public transit.

Recycling

With Pride in the 'Peake taking place in Chesapeake, many community members expressed frustration with the recent decision to remove curbside recycling in Chesapeake. When informed about the option of drop-off recycling, some expressed additional frustration that the drop-off sites are often overflowing. Community members also felt that the way the referendum on recycling was phrased on the ballot was confusing, and listing the $10 cost made the program appear more cost-prohibitive than other municipal investments, despite that not necessarily being the case. Notably, younger participants were much more enthusiastic about recycling.

Many community members expressed wanting the option to participate in curbside recycling and shared that they saw it as an easily accessible method of participating in a sustainable lifestyle that helped to reduce their individual carbon footprint. Additionally, several community members expressed a desire to have more education available to the public about how to properly recycle, including the importance of reducing contamination to maximize the items accepted for recycling.

Green Learning Guides

Many educators and parents noted that they appreciated the presence of the Green Learning guides. We encouraged them to contact us directly if they would like additional booklets for their classrooms. Several appreciated that the standards of learning requirements are incorporated into the learning guides.

Figure D42: Pride in the 'Peake event outreach. Attendees had just participated in the Climate Cash activity

Plastic Free July 2nd & July 9th

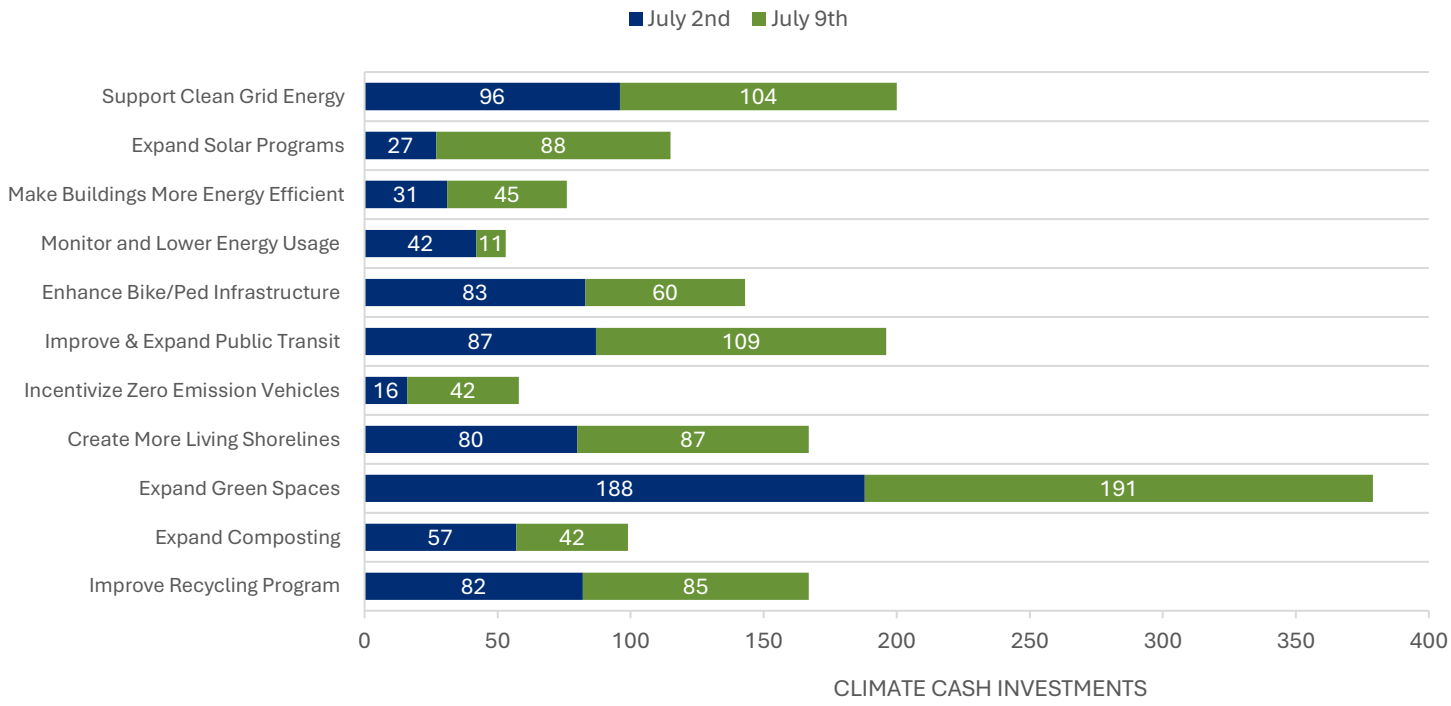
Details: July 2 & 9, 2025, 10:00 AM – 1:00 PM, at the Norfolk Botanical Gardens (

Attendance: 100 (combined over the two dates)

The CCAP Engagement team participated in the Norfolk Botanical Garden's Plastic Free July series, which encourages the public to consider alternatives to single-use plastics and divert plastics from entering the waste stream. The Norfolk Botanical Garden is one of Norfolk's largest green spaces and has a strong commitment to sustainability.

Climate Cash Results

Figure D43: Plastic Free July Climate Cash activity. The bar chart captures data for July 2, 2025, and July 9, 2025



Event Highlights

Expanding and Protecting Green Spaces

Expanding and protecting green spaces received the most support and discussion. Given that the tabling took place at a sustainability event at a large green space, it made sense that the majority of attendees supported protecting green spaces. Many participants expressed the desire for additional green spaces throughout Hampton Roads.

Improve and Expand Public Transit

Many of the participants were interested in improving public transit. Several people compared the public transit in Hampton Roads to other areas they had lived or visited and expressed a strong desire for upgrades and expansion to the current system. They cited that they would utilize it more if it were more reliable and could efficiently move them where they needed to go.

Figure D44: Plastic Free July outreach event. The image depicts participants determining which actions to support with their Climate Cash

Healthy Portsmouth Coalition

Details: June 30, 2025, 10:00 AM – 11:00 AM, via Zoom

Attendance: 20

The Healthy Portsmouth Coalition is a city-wide health and wellness initiative led by a group of community leaders committed to changing the policies, systems, and environments that affect Portsmouth's neighborhoods, health care institutions, community organizations, schools, and workplace to improve health outcomes. The CCAP Engagement Team presented to the group about the Climate Action Plan, as well as encouraged them to participate in Survey II.

Engagement Highlights

Members highlighted the importance of improving public transit, citing that their low-income clients cannot reliably get to necessary healthcare-related appointments and work due to inefficient public transit infrastructure. One member expressed

concern for any plan that does not consider the needs of the Asset Limited, Income Constrained, Employed households (ALICE) population , as they will be unable to access the resources or participate if they are not considered preemptively.

Portsmouth Department of Social Services Event

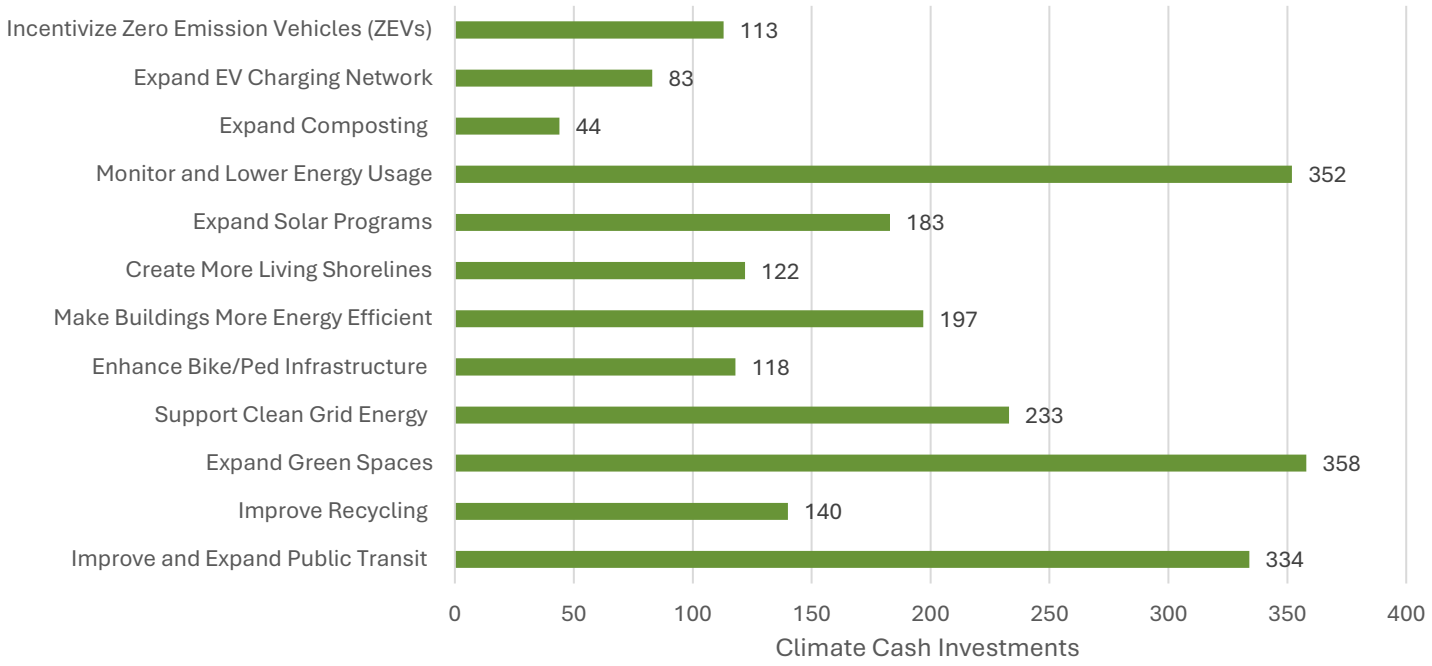
Details: July 19, 2025, 11:00 AM – 3:00 PM, 1701 High Street, Portsmouth, VA

Engagements: 165

The Portsmouth Department of Health and Social Services invited the HRPDC to bring the Climate Cash activity to their annual services fair. This event aimed to connect community members with services, and for the HRPDC, it was to inform and engage the public about the development of the Climate Action Plan.

Climate Cash Results

Figure D45: Portsmouth Event Climate Cash Activity



Engagement Highlights

Public Transit

A common comment was the wish for more transit to go to work or the beach. People were typically excited to win transit passes, except kids who preferred fidget balls.

Green Spaces

We heard several comments about more trees and green spaces. The event was held in a large asphalt parking lot on a 90 degree day so heat was on everyone's mind.

Giveaway Items

The transit passes, earth stress balls, flashlight toolkits, stadium bags, green cups, and pop-it stress balls were popular with community members.

Figure D46: Portsmouth Department of Social Services event, Climate Cash activity

MyFuture757 Event

Details: July 25, 2025, 10:00 AM – 3:00 PM, at the Regional Building, 723 Woodlake Dr., Chesapeake, VA 23320.

Attendance: 75

The HRPDC, in partnership with the Boys and Girls Club and Lead757, hosted the MyFuture757 event at the HRPDC. The event aimed to introduce young people to different careers and initiatives across the Hampton Roads region. The CCAP Engagement Team set up and informed the attendees about the Climate Action Plan, GHG emissions, and the importance of a plan for Hampton Roads.

Figure D47: MyFuture757 engagement event

Newport News Transit Center

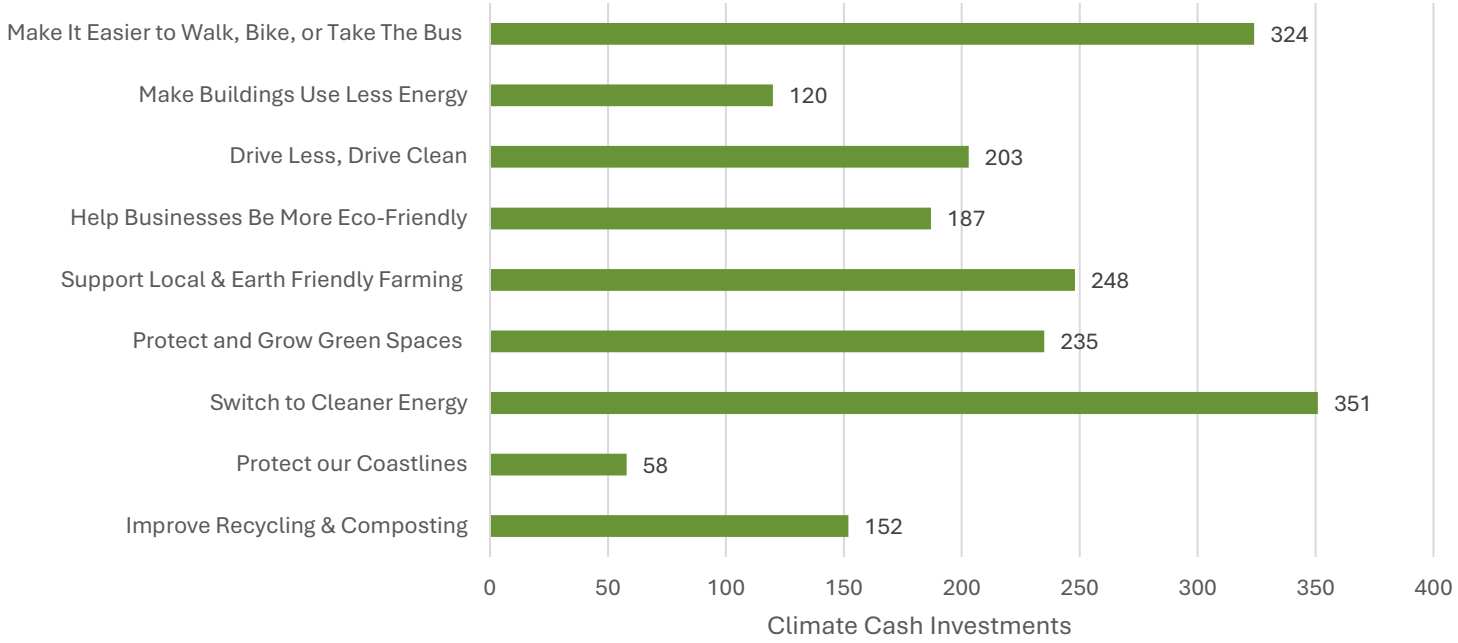
Details: August 12, 2025, 10:00 AM – 2:00 PM at the Newport News Transit Center – 150 35th St, Newport News, VA 23607

Engagements: 136

The CCAP Engagement Team set up at the Newport News Transit Center, which serves as one of the main transportation hubs on the Peninsula in Hampton Roads. The Transit Center is utilized by a large, transportation-vulnerable population. This outreach effort aimed to get additional perspectives from socially vulnerable populations about the proposed actions associated with the Climate Action Plan using the Climate Cash activity.

Climate Cash Results

Figure D48: Newport News Transit Center Climate Cash Activity



Engagement Highlights

Switch to Cleaner Energy

The action with the most investments was "Switch to Cleaner Energy". With many discussing a desire to utilize greener and more sustainable means of energy, but feeling resource-limited, or otherwise prevented. A public comment received stated the following: "*My HOA not allowing solar panels to be installed – we need to push for change*." This comment indicates that while there is a desire to adopt some of these cleaner energy solutions, there may be logistical obstacles to implementation.

Make it Easier to Walk, Bike, or Take the Bus

Almost everyone who came to the table to participate in the activity expressed a desire for greater investment in public transit. Many of the participants indicated that they are reliant on public transportation, but do not feel that it is able to meet their needs. One public comment stated, "*Need more buses. It should not take me 5 hours to get to Beech Mount Drive from Downtown Newport News*." Another written comment stated, "*I had to lose a good job this year due to the buses stop working [at] early times.*" This further cements the feedback from the VMT survey and transportation professionals who indicated how difficult it would be to implement successful and sustainable multimodal options for the public in Hampton Roads.

Norfolk/Tides Game, Newtown Station

Details: September 18, 2025, 10:00 AM – 2:00 PM at the Newtown Light Rail Station.

Engagements: 50

The CCAP engagement team partnered with Hampton Roads Transit again to set up at the Newtown Transit Station in Norfolk. Newtown serves as a transportation hub for three buses and Norfolk's light rail, the Tide. On September 18th, Norfolk's baseball team held a noon game, which the CCAP engagement team hoped to capitalize on in terms of attendance, since the Tide light rail runs along the route for the game. Unfortunately, due to the weather, the turnout was lower than expected. The team was still able to inform and engage with transit users.

Figure D49: Climate Cash Activity at Newtown Station on September 18, 2025

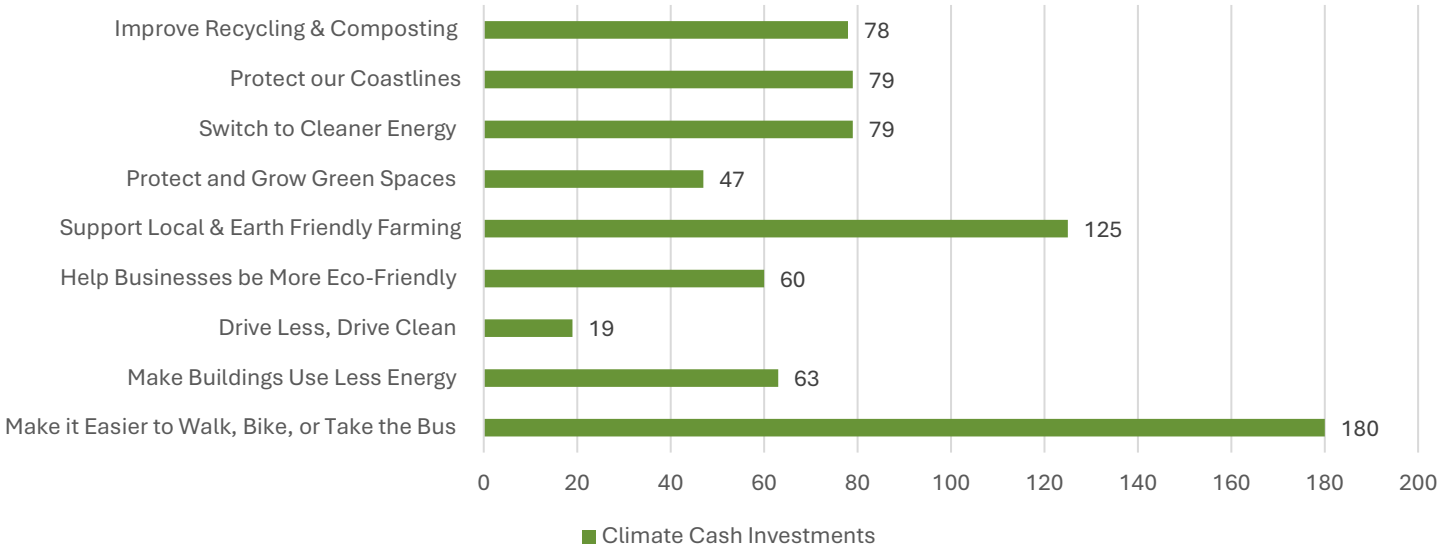


Figure D50: Photo of outreach at Newtown Station. Staff are pictured behind the table with the Climate Cash investment jars

Engagement Highlights

Higher, More Visible Climate Cash Signs

The team used sticks to elevate the labels on the Climate Cash investment jars. Participants appeared to have an easier time reading the labels, and fewer people were observed bending over to see what the labels said.

Climate Cash

For the CCAP, the engagement team opted to utilize a derivative of participatory budgeting, creating a token currency called "Climate Cash" (pictured below). Participants were presented with proposed actions and asked to allocate their Climate Cash, which was available in increments of $1, $5, and $10, to the actions they would like to see invested in.

Participants seemed to enjoy the opportunity to directly influence the "green" investments made in the Hampton Roads region. While the prize wheel was a significant draw, they were not deterred when they had to "help us out" by using their *Climate Cash* to invest before spinning the prize wheel. While the money was not real, many community members took the challenge of prioritizing investments with scarce resources very seriously, and some even took several minutes before determining their final selections.

More on Participatory Budgeting

Climate Cash is a form of participatory budgeting. Participatory budgeting is a democratic process that allows community members to influence how to spend a portion of a public budget. It empowers residents to identify community needs, brainstorm project ideas, and vote on which proposals to fund with real public money. This approach is highly effective for civic engagement because it moves beyond simple feedback, giving citizens tangible power and a direct stake in the outcomes of public spending. Making the Climate Action Plan budgeting process more engaging and transparent helps build stronger communities and fosters greater trust between residents and their government. This direct civic involvement provides CPRG administrators with more insight into potential future spending and implementation funds.

Figure D51: Climate Cash examples

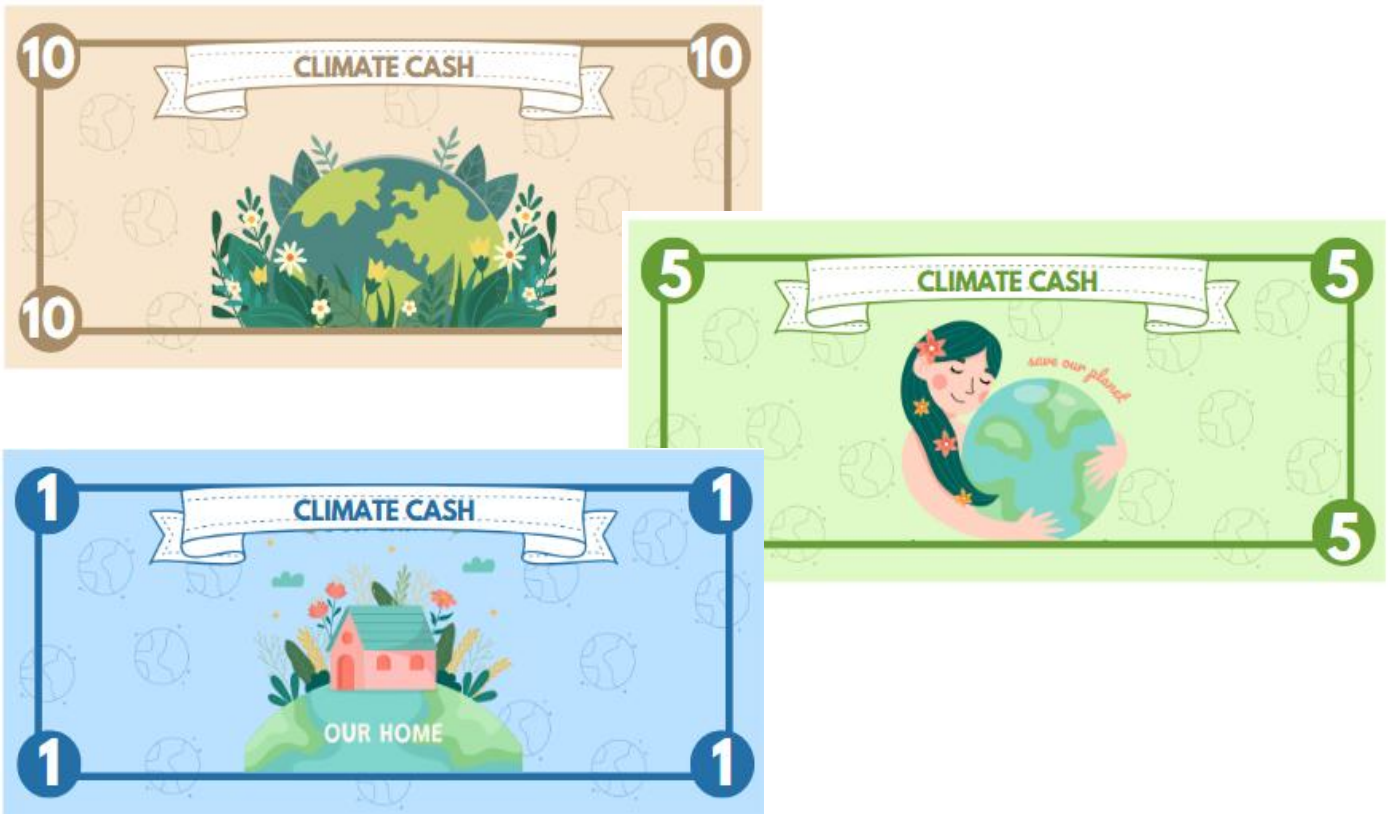


Figure D52: Image of someone participating in the Climate Cash activity

Online Climate Cash Activity

To make the Climate Cash activity more accessible, the team created an online version using Stanford's open-source platform. The online Climate Cash activity was socialized using social media posts and local media email lists.

Figure D53: Online Climate Cash Activity investment results

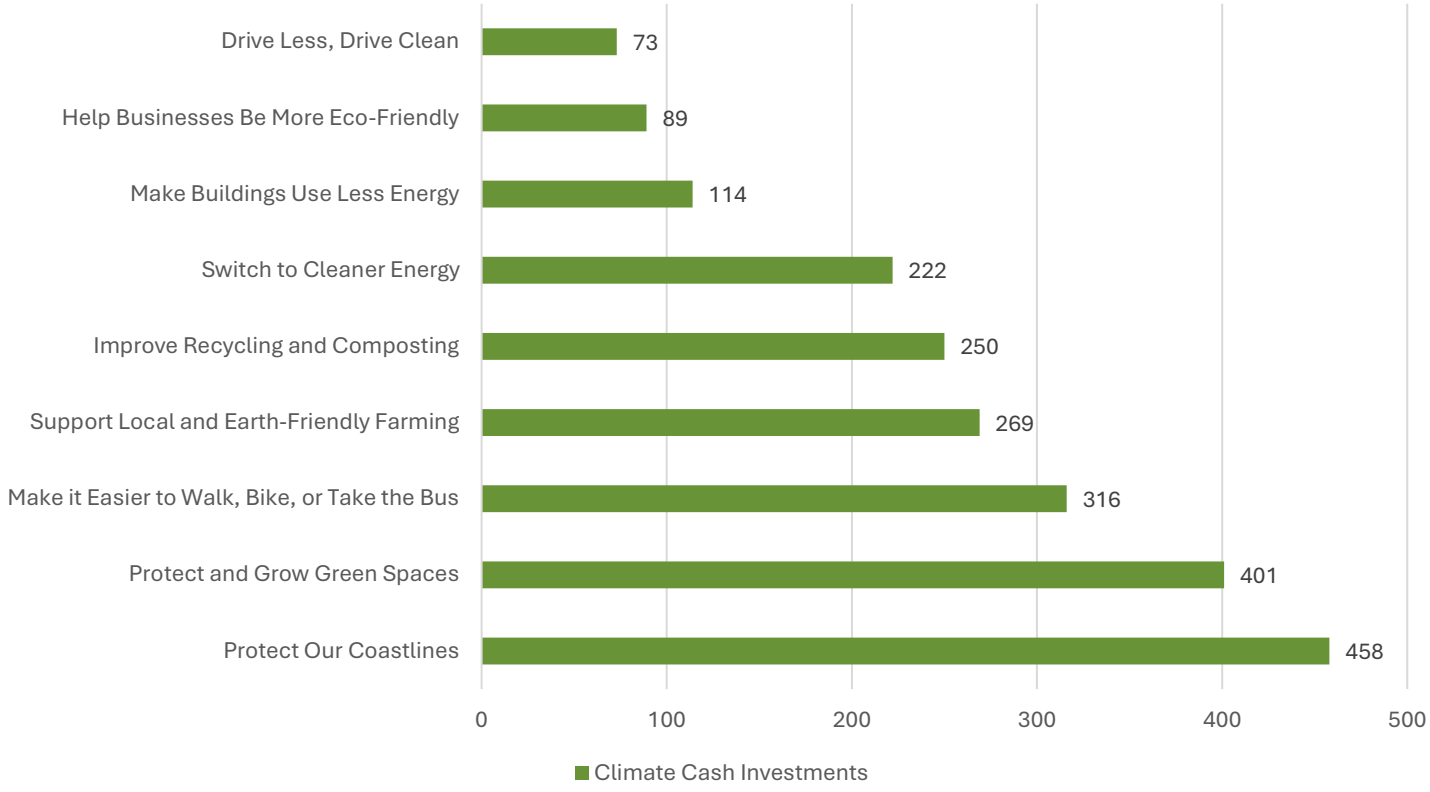
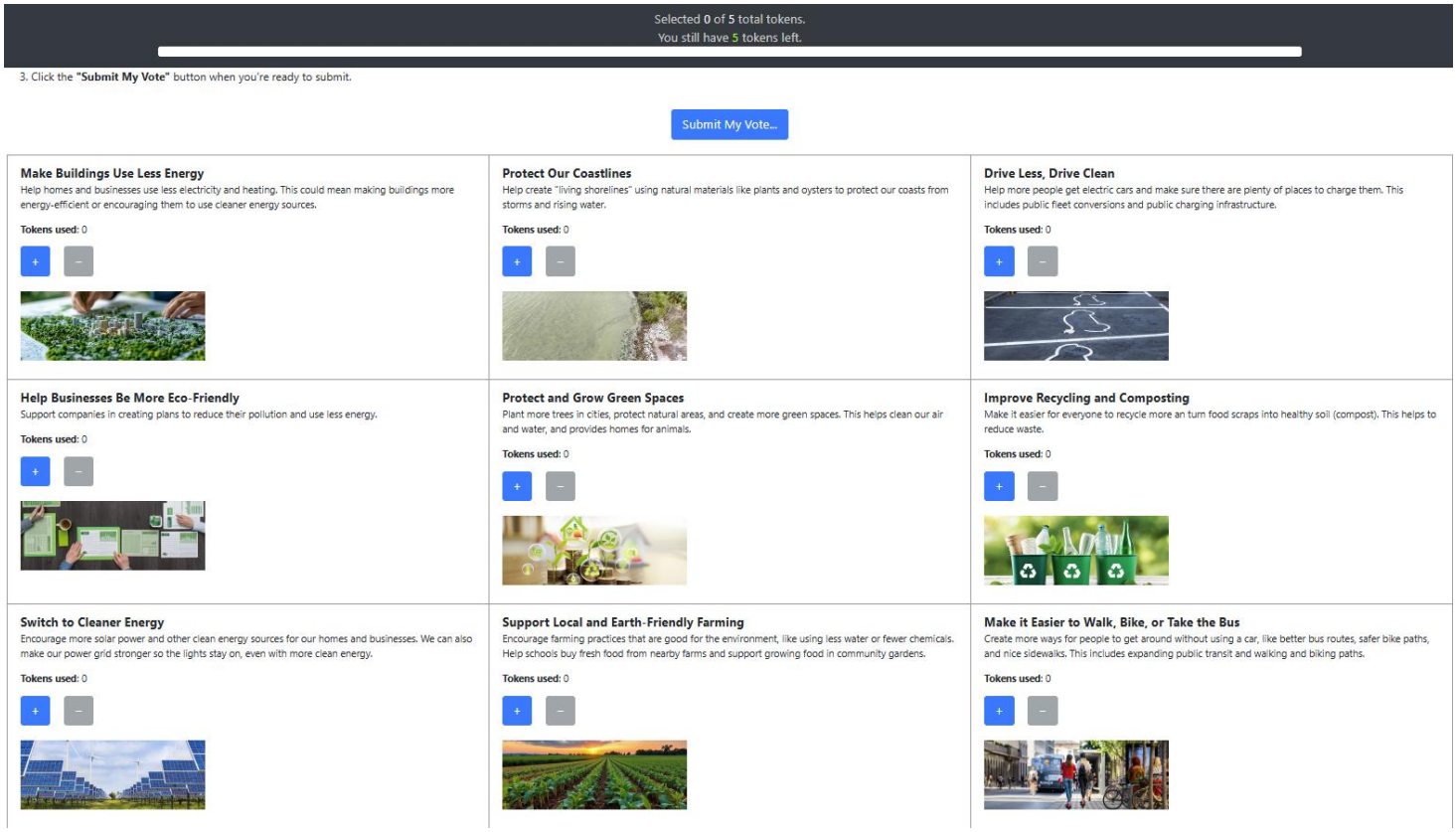


Figure D54: Screenshot of the online Climate Cash Activity



Climate Action Plan Interviews

The CCAP team conducted long-form interviews with members of community-based organizations (CBOs) to solicit community-level feedback from organizations that have established relationships within Hampton Roads.

To compensate interviewees for their time, the HRPDC offered participants a $25 gift card and a handwritten note thanking them for their input.

Questions

1. What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?
2. Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?
3. What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?
4. What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?
    - 4.1. Some examples could include rainwater gardens, community composting workshops, flood insurance resources, and green workforce development programs.
5. What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?
    - 5.1. Please consider what priorities you and your community share that the HRPDC should consider while administering this grant.
6. What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?
    - 6.1. Please provide examples if possible.
7. What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?
    - 7.1. In what ways do you feel like your community is/isn't prepared? How do you anticipate your community being impacted?
8. Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?
    - 8.1. Why do you think it is polluted? Do you know where the pollution is coming from?
9. Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?
    - 9.1. Socially vulnerable people are individuals or groups who face a higher risk of harm, discrimination, or disadvantage due to a combination of social, economic, and political factors. This vulnerability stems from systemic inequalities that limit their ability to anticipate, cope with, and recover from various stressors, such as natural disasters, economic crises, or health emergencies.
10. If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?
    - 10.1. Please share why that change is important to you.
11. Would you want to see the increase of more “green” jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?
    - 11.1. Please try to share why or why not you would/n't want increased investment in these items.
12. What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?
    - 12.1. Would you prefer emails, meetings, posters in community spaces, webinars, websites with guiding information, etc. What makes it hard for people in your community to participate in civic engagement activities such as this?

Interviewees

1. Blair Durham, Black Brand Hampton Roads Regional Black Chamber of Commerce
2. Charvalla West, United Way Virginia Peninsula
3. Aleea Slappy, City of Norfolk Chief Diversity Officer
4. Cierra Lewis, YWCA South Hampton Roads
5. Mary-Carson Sounders-Stiff, Wetlands Watch
6. Vivian Oden, Hampton Roads Community Foundation
7. Tyla Matteson, Sierra Club

Feedback Received

Interviews are ongoing, and responses will be fully incorporated in the final version.

Blair Durham, Black Brand Hampton Roads Regional Black Chamber of Commerce

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I've seen some communications from Matthew Klepeisz, and through general mailings. This outreach is really important because everyone is developing a plan for Hampton Roads of some kind, and that already feels a little hierarchical and hegemonic. I am not necessarily hyper-focused on those efforts unless there is an opportunity for engagement. There is a big regional plan being developed by the Hampton Roads Alliance, and I was involved in the process earlier; it will have a major release in October 2025. Two things typically happen: a plan comes out and communities are not engaged, or the community is engaged, and there is still no equity around what the plan looks and feels like - you have to go beyond the dollars spent to develop the plan. There needs to be an effort to go beyond to determine implementation. I appreciate this engagement effort as thoughtful.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - I have heard about the relationship between our activities as humans (industrial) and how they impact what we experience related to weather. I am more concerned about how the climate-related impacts hit low and moderate-income residents (mental, physical, and emotional health) - I am less familiar with the climate part. I assume there is a warming relationship and ozone depletion, harsher summers, winters, and weather.
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - We need to be prepared and informed. Preparation for natural disasters is not something that gets enough attention. Faith communities have been and can continue to be resources (go bags, supplies for those near water/flooding, etc.). Communities can be prepared in several different ways (improving people's comfort with water), i.e., a local church took a group of people kayaking, and it was about relaxation and enjoyment, but also survival. People should be able to hop into a canoe/kayak and know how to maneuver it. i.e, in Portsmouth, when floods happen, people may need smaller water vessels, so providing inflatable kayaks, source materials, and emergency materials (book bags, water, a list of documents to grab, changes of clothes, etc.). We should focus more on adaptation, resilience, and disaster preparedness plans. Sharing of emergency steps and information. People should know to have health records readily accessible. We should be focused on mindset prep. I am not hopeful for a change in the status quo of emissions - industries and people will not pollute less. We need more support for preparation to deal with the impacts of climate change.

- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - All of the examples are appropriate. I am especially keen on rainwater harvesting and community gardening - they will be essential for future life on Earth. Providing people with emergency supplies, educational materials, and go-bags. Everyone needs to know how to operate a kayak. Inflatable kayaks. Inflatable rafts that can still be used with an oar, in the event of flooding and storm surge (very doable) = there are community members who are off the grid (that may be perceived as more radical), but they're focused on what it could mean in the future and being prepared. Having supplies. Tents.
- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - There are many layers of mistrust; navigating that is as much a part of the work as anything else. This region is incredibly diverse, but its leadership is not. The steps have to be taken to ensure representation at all levels. The way in which people want to feel seen and heard and valued, it has to be seen as a priority for effective delivery of resources otherwise it wont be perceived or received well - representation is not a luxury, it has to be a primary consideration. It is a matter of survival. There is a power building that has to happen, and that also requires a skillset and sensitivity for that to be effective. Advocacy has to be taught when people have been disenfranchised. It requires planning, money, and a strategy for capacity building. The city of Norfolk is putting on a master class as it relates to community engagement when it comes to redevelopment - there are some best-in-class case studies that can be replicated.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - I live in Portsmouth and work in Norfolk. Anything that is bad is just infinitely worse in the Black community. fewer resources, less urgency in responding to issues. Think about the level of pollution that exists where I live, and it's a constant; it gets cleaned up and then it resurfaces (cyclical). I think a lack of pride is different than a lack of care - there are challenges there that need to be unpacked. Those who have the resources tout the wins, but it doesn't trickle down to those who need it the most (could be related to issues of trust) - sometimes a handout is not well received. I feel we are plagued by those issues.
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - A lack of preparation. Oftentimes, with a high concentration of poverty, the focus is on the immediate survival needs, what is needed right now. There is an inability to do long-range planning when financial resources are constrained. Lack of knowledge and awareness, so they wouldn't consider some of the previous resources available. (When it comes, it must be my time, giving in to the bad). Poverty is lower where there is more tree canopy and less heat island effect. Some cities are taking steps to plant some trees to reduce this issue. This grant should consider the additional planting of trees - nice neighborhoods have mature trees everywhere – they may not be gated, but they are shaded. They have an additional level of oxygenation and healthier people. If it is going to be a climate plan, it has to get into the weeds.
- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
  - I often walk to the Portsmouth pier that overlooks Norfolk - as that water comes up in the corner, there is a ton of debris, it gets cleaned, and then it's right back. The people using the area seem to be using trash cans, so where is the debris coming from? The Wheelabrator facility had a ton of pollution. The ground where I live can't be used because of the overexposure to lead, meaning no planting. All of the homes need to have their internal items redone because of lead pollution. In Portsmouth, there is an opportunity to invest in updating (weatherization) of homes, similar to how Dominion does energy kits, and contractors will replace valves to reduce the risk of harm. How do you do away with lead that is in the soil? Help people create raised beds for gardening? When they had a community garden with raised beds, it was successful. It could be done affordably.

- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - Yes, there are, and yes, considerations should be made for them. Often, people who are socially vulnerable may be connected with social services, so I recommend working with case managers who have established relationships - they already have the relations and connections. They already host events, fairs, and love to connect. Even for those who aren't using services, people will still attend fairs to access free resources. It is not dignified to have people wait outside in heatwaves for resources and food. I am aware of faith communities who have dropped off packages at the door; that is dignified. Dignity is important in the administration of resources. Humans deserve to be dignified in life, not just in death, but also in the way we provide these resources.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - Something to do with water – I am not confident that the current water that runs through the facets is safe. 2) The amount of water that we need to be consuming on a daily basis is not affordable. A family of four where everyone is under 200lbs, needs approximately 100 oz a day. I would like to resolve this issue and find a sustainable drinking solution that is both accessible and healthy. Does it need to be alkaline or spring water?
- **Would you want to see the increase of more "green" jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
  - I would want to see these things as outcomes for sure - 100%.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - Having a presence at events. Partnering with folks who produce events. Strategic ads on social media. The news media is still credible - press releases to different outlets would be important. Strategically placing literature at community venues (Norfolk Assembly, coffee shops, barber shops, hair salons) and building partnerships with those types of convenors, centers of community influence, and churches. Maybe they could be incentivized to convene in partnership or on behalf.

Charvalla West, United Way Virginia Peninsula

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I don't have much background. I participated in the climate action plan survey previously. I participated in the James City County RAFT project.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - I am familiar, but not in the scientific sense. My knowledge is from media/social media/politics (because of recurrence in the news cycle). I have also heard about sustainable alternatives.
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - I would like to know more about what the most common uses of fossil fuels are. What are the causes of climate change as they relate to fossil fuels? What are the right alternatives? What does access and affordability look like for most people? As an organization (non-partisan), it would be helpful to inform the people we serve about affordable options that are good for the environment, now and in the future. One way is to educate other non-profit organizations, who are talking with people every day (especially those needing energy, water, utility needs, or a broken-down car). We are already on the front lines of helping people who are using fossil fuels, but don't know how they are impacting climate change. If there are affordable options, it would be nice to offer them to people, especially those whom we are helping with utility bills. It would be helpful to partner with the Department of Social Services since they do energy assistance (heating/cooling). Weatherization programs. As well as opportunities to inform people who would not otherwise know. Social media could be helpful, but it is not always easy to discern misinformation from accurate information.

- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - Opportunities that mitigate flooding, and turn that water into a resource by redirecting it somewhere else (stormwater management) have less flooding, put infrastructure in place to mitigate flooding, and then use that water for drinking or other needs. Solar has been a big option that has been afforded to homeowners primarily, more opportunity for high-density housing (apartment complex) to add solar to offset the costs of tenants, or as a subsidy. I don't know a lot about wind as an option. Power lines being underground vs. above ground. Investments to move lines underground as opposed to above. It would add to better resilience for disasters. Anything to offset the costs to individuals in households for using clean energy as an alternative. Dominion recently requested approval from the state to raise fees for users. There is a new program by Dominion that bases users' bills on income, and that cost has been shared and added to everyone's bills.
- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - Be informed by the community. (It is frustrating when administrators move forward without community involvement beforehand.) Sometimes "climate change/resilience" is aspirational for some of us, especially those of us experiencing or trying to meet the needs of basic humanity, so the idea of adding clean energy priorities to those serving or those being served can sometimes fall off the list of priorities. Any efforts to connect clean energy to improving lives right now would be helpful to have organizations prioritize alongside. It sounds very scientific, so helping to bring along community leaders would be helpful. So much of it is politicized, so it can be hard to keep up. There is also the capitalist side of it as well - i.e., solar salespeople knocking on doors doesn't feel like helping the planet - acknowledging the capitalist/economic side and how that gets translated. Education and information. I have been invited to serve on the state-led effort advisory board for clean energy jobs. The plan should consider workforce development programs.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - There is real concern for downtown Newport News related to coal dust and air pollution. I have not heard any feedback about shipbuilding manufacturing causing pollution. Perhaps they could serve as a model to follow if they are already mitigating pollution and emissions. In terms of natural disasters, our community experiences significant flooding in certain areas, particularly in regions near rivers, even if localities are not located by the bay. For instance, James City County has some areas susceptible to flooding. Poquoson experiences frequent flooding, which makes it more expensive to live there. Local government emergency management does a good job with training and involving the community. We do spend time when the weather is beautiful, planning for eventualities.
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - Should there be a weather event forecasted, is everyone in my community going to know? Because of recent events, including investments in broadband, cell phone data, I believe most people will be informed. Will they have the ability to prepare? There is an opportunity there for those who don't have transportation, for our system (human services) to allow preparation, which would ensure those individuals get the transportation needed. Would our system, built on crisis response, be able to prepare? Would we have food and medicine ahead of the event, and quickly? Is it possible to elevate the safety net to ensure people are prepared ahead of time? Who has the shelter, and are they going to have the resources (food, medicine, supplies) needed ahead of time? I am concerned about cost restraints, resources, and labor constraints. I think of the impact of Katrina and the similarities with our region. The refugees had nothing when they left. The response to Katrina was so slow. We need to be prepared in case Federal Emergency Management Agency (FEMA) is not available. What is our capacity locally to respond?
- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
  - There are certain parts of the Peninsula where mold is more pervasive. It may be related to sitting moisture. I would also reference the Newport News coal facility.

- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - Many seniors have a unique vulnerability even outside of age, physical, or medical needs. Many are not connected to social or natural supports. Aside from SES, which can create a lot of vulnerability, especially in times of disaster. There are many seniors in gated communities, closed off, living in larger homes, not able to weatherize or prepare those homes, especially in the event of extreme events, and family is not here to help. Isolation of seniors can be uniquely challenging. Homelessness/housing instability - very vulnerable to these events. Those hosting unhoused individuals may feel a heightened sense of scarcity, which threatens their safety in the event of an emergency, and accounting for these individuals can be difficult. A lot of the people are children. A lot of people live in hotels/motels. If a hotel can't operate, then it has to close, and everyone has to leave - a unique vulnerability that is not accounted for or considered. People who live in mobile homes, because they're less sturdy and older.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - More communal transportation that is climate-friendly. I think it would have broad positive impacts across the community (disaster response, preparedness, quickly get to the pantry, pharmacy, etc.), and be more accessible. Generally speaking, it would mean more jobs, and people could move more easily in the community. It would also impact tourism, health, the workforce, and other areas where we want to see positive change. The “support” system would be able to respond quickly.
- **Would you want to see the increase of more “green” jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
  - Yes, I would like to see more “green” jobs, especially if they are going to pay livable wages.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - I like receiving infographics and concise digital communication (emails), community presentations, and conversations, hearing and participating in those. They are great ways for me to educate and be informed.

Aleea Slappy Wilson, City of Norfolk Chief Diversity Officer

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I know a little bit about it. A colleague is on the steering committee for the CPRG. I want to make sure that we are thinking about all communities, proximity to pollution zones, including shipyards, impact from climate change, and other factors.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - I’ve heard about it, but I couldn’t share anything specific. Things enter the air that are pollutants to people.
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - It should be woven into more regular conversation. Specifically in Norfolk, if we have a weather emergency, then we talk about climate impacts, but we don't weave it into regular conversation. Everything about it seems like it only comes up in weather-related emergencies.
- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - Revisiting the role of recycling and plastics. I feel like in Hampton Roads, we don't even talk about it anymore because we haven't made a regional commitment to recycling or its impacts; it's left up to each city to deal with it. Any education or program that can help people see the interconnectedness of the climate would be helpful. There are things that get more attention, like rainwater gardens, but simple steps like recycling and adjusting our relationships with plastics and other non-biodegradable materials. This should especially be talked about with kids. What about the conversations that used to happen around the ozone? They don't seem to come up anymore. There seems to be a disconnect.

- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - Communities in particular that don't have access to some of the information related to composting, sustainability, etc. Grant administrators should be going to communities that haven't been invited into the conversation. There are folks who will seek out the information, but other communities don't even have it in their sphere, not for lack of care, but because it hasn't been brought to them yet. Then let them decide their level of involvement.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - The "Southside" area of Norfolk (Berkeley, Campostella Heights, etc.) doesn't have access to resources in the event of emergencies. In the event of an emergency situation, such as flooding, they would be disconnected if the tide were high enough. How do we ensure an entire part of the city isn't left out in the event of a natural disaster?
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - I think my community is prepared in relation to connecting to neighbors and social networks. Whereas connectivity to city resources does not seem to be the same. Not everyone has the same social network, and not everyone is connected to the Norfolk governmental administration (i.e. receiving emergency alerts). We have done campaigns to sign people up for alerts. If people are not connected to the alerts, they could be vulnerable. There also seems to be a larger connectivity that is missed.
- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
  - The shipyards. They have direct connections to communities and are in close proximity. I believe pollution exceeds what should be allowed near communities. I was on the Southside task force addressing community concerns, and people would talk about going outside, and there being a layer of soot on their cars. It is not happening elsewhere in the city. If that is on the car, what is in the body? That is the biggest concern. The proximity of residents and schools to the shipyards. Another area is Lambert's Point (rail yard). I am also concerned that there is not a current solution.
- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - All of the above, yes. They're experiencing disadvantages based off of identity markers, lack of social capital, lack of education, and zip code. They should be considered first in the plan. Anyone who has been historically disadvantaged, including identity markers, should be considered first when developing the plan.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - It would be the combination of education, and reasonable sized amounts of money (grants) so that they can make the changes that make the most impact at the individual level and make sense for them. I would keep administration out of it. Community block grants for civic leagues/neighborhoods to determine the next move, paired with education and creating a knowledge base.
- **Would you want to see the increase of more "green" jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
  - Swimmable and fishable waterways. Connecting back to plastics, if people felt the waterways were cleaner and the fish weren't consuming plastics, people would pursue their own food more in a more healthy and sustainable way.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - Through places and channels that are already being used. Not something new. Folks already go to the supermarket, for example. Putting it in new places on new platforms makes it more difficult to access.

Cierra Lewis, YWCA South Hampton Roads

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I am newer to the topic. I was invited to previous CCAP meeting, but am unfamiliar.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - That is the summation of what I've heard. There may be incentives for solar panels.
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - We know that greenhouse gas emissions are bad for the environment, but we need more information about how it impacts the weather and climate. I see news stories, but how does it impact people directly tied to Hampton Roads and our community? How does it affect marginalized groups? We should make it more accessible for people, who are not regularly in those spaces [climate conversations]. We can convey information through art. A great example is the Underwater Projects documentary or Dr. Finn's exhibit at the Museum of Contemporary Art. The information can be connected to lived experiences, and people connect to art. Put a face to the issue. Try collecting more testimonials of people impacted or doing the work, or partnering with WHRO to humanize the work so that people can see it, and it is more relatable.
- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - Flood insurance resources. A lot of people don't know how bad it floods in Hampton Roads who are not from here. Community composting workshops. Green workforce development programs; that hits multiple different goals including workforce, economy, equity, and job shortages while making it sustainable. People have not always cared about the environment here, and polluted the rivers, so being able to educate and rectify that would be important.
- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - It would be important to consider marginalized (Black and Brown communities and how they have been historically disenfranchised). Acknowledge environmental racism. Include heat mapping. When rivers are polluted, what communities are impacted? Flooding, who does that impact? Resources for those who are experiencing flooding (prevention of going to school, work, etc.) Investing in Hampton Roads public transit infrastructure will help to address transportation emissions. A barrier to access is often transportation. Look at incentivizing GoCommute and microtransit. Invest in bus passes for low income community members and public transportation.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - Flooding is the biggest thing. How do you navigate a place that always floods? We don't always think about the cost such as wear and tear on cars, including smaller ones that are more inundated with water. It's a safety hazard to drive through flooding and water. There is a need for tree mapping, and more access to more trees and cleaner air. We need more education, and we need more talk about environmental education. There needs to be conversation/community education about lack of tree canopy. Providing this information to the youth so that they can make more sustainable decisions. For example, fast fashion is causing a lot of environmental issues. If fast fashion stopped, there would be enough clothes to last us all for years. Considering the potential of climate-induced migration. Do people in the flood zones have supplies (rain boots, umbrellas, etc.)? These can be barriers to access for students, and they may not get to school. Norfolk tried to provide students with those resources it was grant funded and included safety equipment.
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - Heatwaves have good socialization on social media – there is a lot of information circulated about cooling shelters and other resources on city websites, news, etc. I don't know how prepared Norfolk is for flooding. I've been a resident for 6

years, where I live there is a little bit of flooding, but I have never been told that I needed to evacuate. I think I am safe, but I am unsure about other neighborhoods. We are not prepared for snow - we only plow main roads, but not secondary roads for potentially vulnerable people like the elderly, low-income, etc.

- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
  - I think about the "Underwater Projects" documentary. There were neighborhoods in Norfolk and Portsmouth that were more vulnerable to flooding. In Newport News I think about the shipyard and coal facility - are they making sure to follow practices that prioritize the health of the surrounding communities?
- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - Yes, people in a low SES, living below the poverty line. A community garden would be great for access to fresh food. When it floods, check on them as well. Consider the elderly and seniors who need assistance.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - More green spaces so more people can go outside and enjoy cleaner air, and experience less respiratory issues like asthma, and also have improved mental health. Some sort of eco-friendly public transit. In cities with better public transit, there is less air pollution, More connectivity and more accessibility. More access to workforce solutions, upward economic mobility opportunities – that adds property value and reduces crime. There is everything to gain and very little to lose with more sustainable transportation solutions.
- **Would you want to see the increase of more "green" jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
  - Yes to all of the above.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - Newsletters, videos (TikToks or short form), WHRO interview. HRT has a podcast (Going Places).

Mary Carson Sounders Stiff, The Wetlands Watch

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I am familiar with the grant funding the plan. I was unsure if it was still happening. It is broad, inclusive, and ambitious. Hampton Roads is a giant geographic area with a lot of different community profiles, and locality positions. It's also across state jurisdictional boundaries, which is interesting and important, but likely challenging from a planning standpoint for policy changes. I am interested to see how that is bridged - how to account for nuance of policy in law in NC vs. VA. The scope of the plan may not allow for concrete recommendation implementation actions. Maybe they'll be less policy-based, and more on a recommendation, such as here is how you can adapt and mitigate. How do we do this is important. While also moving towards the next steps of carrying out the plan. I think that it is really needed. Other areas in the country are moving towards this, and our region has been focused on adaptation, and not a lot of time on mitigation of the impacts. I am interested to see how our government and people balance those two things, and the balancing of economic priorities.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - I am very familiar. My whole career is built on that reality. The cause of climate change and it's impacts, to our organization, is known, and clear, and undeniable. Where we do not go is to try and convince people whether it is real or not real. We meet communities and localities where they are - some localities don't believe in sea level rise (they call it erosion) - our approach is "we don't care why it's happening, it's happening let's get moving on the action". There are many orgs that know that it is true, and work in this space, and their crusade is to convince. Our organization focuses on adaptation and mitigation.

- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - Going to the communities, connecting with community based organizations, and meeting with them during a previously scheduled and continuous meeting (civic league, church, etc.) and then talking to them about what they see, and what they experience, and asking people to share their lived experience without telling them what their lived experience is. We don't start with "Hey ya'll have got some problems", we start with "Talk with us about what problems you're seeing." Unless specifically invited to speak on climate change, and in those instances, we still ask what they are experiencing. And when we talk; development decisions often come up, and the temperature is changing, and water is rising, and the geomorphic pressures that have played an additional role (melting glaciers), and the human impacts. In our region our land subsidence is more severe than sea-level rise. We talk about groundwater withdrawal (paper mills, aquafers, filling in creeks to build houses), we are not just focused on pollution and industrial revolution impacts.
- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - Adaptation. Yes, to the examples. Funding for neighborhood scale projects - get neighborhoods assessed, and then the development of neighborhood action plans. The Aberdeen Gardens assessment in Hampton is an example. How can we help bridge that gap for them through that work. Green infrastructure workforce training. Connecting young people (universities) to this work helps to get young people to care about this issue. Engineering and design firms are overwhelmed and don't have enough workforce, so that helps create funnels. any sort of regional collaboration - multi-scale adaptation efforts. Water rising knows no boundaries. The Army Corps study in Norfolk and Virginia Beach. There's an opportunity for them to collaborate with one another via shared payments - allowing Virginia Beach to tie into one of those gates. Helping the entities making the spending decisions know that they can work together. It can be improved in shared resource spending space. Regionalism can be improved by cost sharing and leveraging shared resources better.
- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - What is most important to focus on (mitigation vs. adaptation) is a real issue – they are competing forces for money and attention. We have to do both. How do we do both? How do we prioritize funding for one over the other, and attention for one over the other. We try to work in underserved communities, sometimes it's difficult to get people to care about flooding when they are trying to get food on the table and trying to navigate the safety of their kids, or are fearful of political things happening - these are things members of the community have shared with us. How do we raise it to a sense of urgency when basic needs are not being met. There is a way to get there, i.e. it is too hot, (Urban Heat Island effect) and the need for more urban tree canopy, that is inextricably connected to land use planning, similar to flooding preventing ability to get to work and school. Flooding is just one more thing for people who are just surviving to worry about. It is an issue articulated to us and our partners doing this work.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - Getting the government to care and show up for them is the number one thing. Getting someone to care. Having their voice heard and responded to. This is happening across SES lines. People feel like the government is failing them. Not saying that the voices of higher SES neighborhoods don't get responded to quicker or more likely to get attention compared to lower SES. There is a lot of community associated guilt that can be impactful in certain neighborhoods. There is a history of intentional neglect that is unparalleled. Getting the voices heard and the government to do something.
    Funding - people are frustrated that funding is going to things not aligned with their priorities. An example is the flood wall in Norfolk. Some people are upset that could or could not be protected by the wall, but the wall is also being driven by other forces. Stormwater, resilience projects, and they all cost a lot of money. Neighborhoods are feeling more and more behind. We need cost benefit analysis. The Southside neighborhoods in Norfolk were left out of the flood wall plan due to a lack of "benefit".

- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
    - It runs the gambit. Neighborhoods with means are more prepared. They have more generators, while neighborhoods with less means have less generators. Those with generators are able to keep food in the fridge cold and take a hot shower – and are in a different mindset than someone unable to do so. An example are people reliant on oxygen, medical devices, or pumps for diabetes during power outages. The economic disparities are the biggest. The neighborhoods that are connected may do more resource sharing. In the communities with more means they are more prepared. In neighborhoods that are connected, there are more resources. In neighborhoods with less resources, people with the most vulnerability, who are not connected via faith communities or social ties, there is more risk. Those without vehicles are at higher risk, especially in the event of emergency situations. We could be more prepared via flood insurance information. We should encourage people to get to know their neighbors and ensure that there are emergency plans in place that consider the vulnerable in the community.
- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
    - Yes. Neighborhoods near industry, like the Newport News coal terminal and the nearby new builds, that is not good for people or their health. So many kids have respiratory issues because of the coal piles – It is a very irresponsible and predatory development. The city should not make those lands developable. Any neighborhoods near industry, development, near economic corridors (pollution from big box stores Walmart, Lowes, etc.) the drainage is then redirected to other areas exacerbating environmental impacts. The septic tank issue is related to equity and EJ. Suffolk was a focus of a National Public Radio (NPR) study - redlining of communities, and the placement of people on rural lands with the bad septic tanks that are non-percing, the systems are going to go first on the lands that don't percolate and it could mean people losing their homes.
- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
    - Yes there are socially vulnerable communities - getting them to care is going to be a challenge. We must do it respectfully, and not critically. We don't necessarily have the answer, but it is good for more knowledge.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
    - More money and more rules on how to spend the money equitably. The problem is that the work has to be done at parcel, neighborhood, local, regional, state levels all at the same time. It requires all the plans and collaboration together, which requires money and investments. (i.e. stormwater work, remove people from high risk and unsafe places, paying people equitably for work.) The problem is there is not enough money to do this work. There isn't enough money, which makes it become politicized.
- **Would you want to see the increase of more "green" jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
    - [skipped due to time constraints]
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
    - [skipped due to time constraints]

Vivian Oden, The Hampton Roads Community Foundation

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - I'm not very familiar with the plan prior to this interview. I knew about the work that Dr. Johnny Finn is doing by way of the social justice conference at CNU. I am doing a learning workshop with Dr. Finn.
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - Just how it can impact different communities, cause hazardous conditions. It tends to impact communities that already have low SES, or are environmentally burdened like those near landfills. Many tend to be communities of color.
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - More of what is being done. The work that is being done to address it in our communities. How are we educating people about it? How do we get into the communities impacted and involved? Many could not be aware of the damage that is caused by environmental factors. Making sure that people are aware of those environmental connections. There is an opportunity to do more education.
- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - Currently, the Hampton Roads Community Foundation doesn't do a lot of climate related funding – although we have done sea level rise projects. Doing more projects around EJ. HRCF has done some greenspace projects with local colleges (TCC). I would love to see more green spaces and green canopies that can reduce the urban heat island effect, especially in marginalized communities. EVMS was doing some work with low-income housing and mold and indoor smoking being connected with respiratory wellness. I would like to see projects funded for modernization and weatherization for low income and older housing. making sure everyone has access to clean water and being aware of those who may not. I am concerned about the railyard and Lambert's Point neighborhoods. Additional buffer zones around highways/interstates for improved air quality.
- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - Making sure there are equitable practices in place. We tend to go with organizations that we know, which tend to be larger, so the smaller organizations with less relationships tend to be overlooked. Making sure that funds are equitably spread among organizations and CBOs. Think about the impacts on marginalized communities. Get community voices involved in the decision-making process in the selection of grants.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - Access to resources - not being aware of the resources that are available and how to access them. At one point there was a collective effort to put together a collection of regional resources for people to access and review. People may "hoard" information and not share it as needed. They don't know things that are happening.
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - I think that we're not prepared for large storms or extreme flooding – and we are similar to New Orleans. I think about Norfolk and Portsmouth, and the impacts of flooding. I remember it being flooded so bad in Norfolk that I had to wade through water to get to my vehicle. I am working with ODU on resilience through their Coastal Center. They are working to help prepare the region for the impact of extreme weather events and how to get resources to the community, and help support; including flood insurance, kids being displaced and school. Resources should proactively be in place, and there should be a clear plan ahead of time of where to go, how to get resources, especially considering signal and communications may be down during those events. Evacuation would likely be a major disaster for Hampton Roads

considering the current evacuation routes. Know Your Zones, does not seem effective enough. People don't know their zones or what to do. What regional coordination exists?

- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards?**
  - Lambert's Point. Chesterfield Heights (Grandy Village). Newport News near the coal facility and industrial sites. Downtown Suffolk could potentially be a concern.
- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - Our redlined neighborhoods. Many of them are already impacted and overburdened by environmental factors. Those who are most vulnerable to environmental hazards should be focused on.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - Creating a plan to have access to resources (basic needs) for resource strained and socially vulnerable communities, such as community gardens, pantries. This is often complicated by city and town boundaries. I would create resources across lines.
- **Would you want to see the increase of more "green" jobs, cleaner and more modes of transportation, increased property values, and swimmable/fishable waterways?**
  - I would like to see cleaner and more modes of transportation. Our public transportation could be so much more effective. I wouldn't necessarily say increasing property values - instead I would want REAL affordable housing that is accessible by the average wage. Yes, to more swimmable fishable waterways. The green jobs need to have thrivable wages that people can use to not just live, but thrive. We need to create more and better agricultural opportunities for farmers.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - I'd like to learn from the people that are creating the plan. Specifically it would be cool to hear from people who are impacted by the development of the plan. Especially those from vulnerable communities. Updates on the website. Testimonials would be helpful.

Tyla Matteson, The Sierra Club

- **What, if anything, do you know about the Climate Action Plan being developed for Hampton Roads?**
  - [skipped since Tyla is on the CCAP Steering Committee]
- **Have you heard about how things like burning fossil fuels can affect our weather and climate? If so, what have you heard?**
  - [skipped since Tyla is on the CCAP Steering Committee]
- **What more do you need to know about greenhouse gas emissions, changing weather patterns, and extreme storm events? What's the best way to inform your community?**
  - Informing the Peninsula, via media outlets, social media, newspaper, first of the month events, pop up events, fairs, and engaging with the community.
- **What kinds of projects would you like to see funded through climate-related funding in Hampton Roads?**
  - To capture the general public, it would be good to have hands-on projects like rainwater gardens. From the POV of what we need to do in regards to urgency, we need to fund solar arrays, EV chargers, electrification of buildings and personal homes. In general; electrification.

- **What are the most important things that you'd like grant administrators to consider when deciding how to spend these grant planning funds?**
  - The Sierra Club's number 1 priority is climate change. Looking at opportunities for the biggest impact. Such as EV chargers, encouraging localities to buy EV chargers, E fleets, and not investing in propane switch over since it is a fossil fuel. Transportation like trains, trolleys, bicycles, and pedestrian lanes.
- **What are the biggest challenges your community faces related to things like weather, pollution, or access to resources?**
  - Air pollution that occurs near the coal facilities in downtown Newport News. They blow around a lot of toxic air/coal dust. This also happens in Norfolk. Pollution from automobiles. If we had more EVs, we'd have less of that. We have high rates of asthma in those areas compared to others in the regions. Those areas tend to be low income/minority. A lot of those families may not have the resources to move elsewhere. It would be good to have inhalers and medical resources for the kids at schools.
- **What comes to mind when you think about your community being prepared for high-risk weather events like floods, heat waves, or extreme storms?**
  - Hampton is very aware of the risk of these extreme storms and floods, and spends a lot of time on awareness and preparedness. But you never know how bad it can be. Over the past 15 years it has flooded over 3 times. The canal near Riverdale in Hampton overflowed near Langley Airforce base. The flood map projections show a lot of Hampton under water, unless they Figure Dsomething out. Areas impacted include Buckroe Beach and Grandview Nature Preserve.
- **Are there any places in your community where you feel the air or water isn't as clean as it should be? Or where people are overexposed to pollution or other hazards? Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - There are incidents of water bacterial pollution from overheating of the water. It is more pronounced now with climate change. Different diseases that are becoming more common. If you have a scratch and get in the water, with an open wound, you can get seriously sick or injured. There is fear that this could become more common. There is also a lot of traffic from tankers, who are possibly not disposing of their waste properly.
- **Are there any socially vulnerable people/populations in your community? Are there any specific considerations in the plan that should be made for them?**
  - The people who live in Azaelia Gardens in hampton (historically African American community) has applied for grant, but did not win one. The area does flood regularly. It would be important to preserve those wetlands – they are former wetlands near Chesapeake Avenue.
- **If you could change just one thing to make your community healthier, safer, and more sustainable, what would it be?**
  - Electrification - cheaper heating, with heat pumps, energy efficient buildings, EV charging stations, using more EVs, solar could be the source of energy on municipal buildings, fields, residential, and commercial.
- **What's the best way for you to learn about things that might affect your community, like the development of the Climate Action Plan?**
  - In order to have localities buy in, people need to communicate with their elected officials. The most permissible way to do that is to go to the meetings and speak at those meetings about their concerns, priorities, and how to address climate change. I encourage having an adhoc committee that focuses on sustainability and focuses on getting this information to councils and elected officials. Norfolk has a climate action plan. Virginia Beach has sustainability goals. The best people to come are young people. Having a group of approximately three rotate in and out of speaking lets the council or CAO see that there are people in their community that want to see a change. Make it engaging and less threatening.

Public Comments

No public comments were received during the official comment period. However, the informal feedback provided on the draft was considered during the review process and revisions.

Lessons Learned

The engagement and outreach process for this grant has allowed the CCAP team to review different methods and adjust their efforts in hopes of yielding greater success in future engagement efforts. The CCAP has allowed the team to try new approaches to engagement.

Participatory Budgeting

When conducting initial outreach events the team did not have an activity or an engaging way to get the public's attention for the Climate Action Plan. They noticed that other tables typically had an activity, even if just a prize wheel, to draw the public in. Additionally, the team noticed that it was difficult to persuade people in public to stop and take surveys related to the Climate Action Plan. Taking a survey in public at an event was seen as too involved or burdensome by most of the public approaching the table. The team discussed ways in which they better educate, engage, and involve the public in the Climate Action Plan, and discussed different potential activities.

Ultimately, the team landed on the Climate Cash activity. There are several examples of civic engagement using "funny money". Using "funny money" **gamifies** the complex process of budget allocation, transforming it into a simple and tangible exercise that is more accessible to the general public. This hands-on approach makes civic engagement feel less intimidating and more immediately impactful, as people can physically or virtually "spend" their money on the projects they value most. It also allowed the CCAP team to have additional data points and insights related to public sentiments and priorities related to the Climate Action Plan and the associated actions.

The Climate Cash activity quickly became popular during outreach events and was well received by the public. The CCAP Engagement team noticed that overall, participants of all demographics would take their time and consider where they were placing their Climate Cash investments. Due to its success, the Climate Cash activity was even specifically requested by the Portsmouth Department of Social Services for their July 19th event.

Gamification and Digitization

The CCAP team noticed a slowdown in responses to Survey II and suspected that the survey might be too technical or lengthy. The team then discussed digitizing and further gamifying the Climate Cash activity. They explored different online platforms for participatory budgets and landed on the Stanford Participatory Budgeting Platform and Polco as the two platforms that could offer what the team was looking for. Stanford's Participatory Budgeting Platform is open-source and free, but Polco's quote exceeded the HRPDC's budget. Therefore, the team opted for Stanford's open-source and free product that offered most of the functionality the team was seeking.

The Climate Cash activity was then added to the Climate Action Plan webpage. Shifting the gamified budgeting process to a digital platform makes civic engagement more engaging by removing physical barriers and allowing residents to participate from any device, at any time. This approach is helpful because it significantly broadens the community's reach to a more diverse audience and provides immediate, transparent results as collective priorities take shape in real-time. It also provides a more

straightforward way to interact with the concept of Climate Action Plan actions and measures, particularly for those unfamiliar with the topic.

Simplifying Language and Accessibility

The team quickly found that not everyone was familiar with the concepts and proposed actions initially featured as part of the Climate Cash activity, due to the technical phrasing used. Over time, the team reduced the number of actions displayed on the mason jars by combining some of them and simplifying the language. This made the jars with the attached actions more visible, the choices to choose from feel less overwhelming for participants, and the overall activity more comprehensible.

The team also noted that in the future, the labels should have backgrounds that better relate to the action, rather than a generic green space background. Additionally, the team plans to make the labels higher on the mason jars so that they are easier to read.

Location Informed Sentiment

The team noted that, based on the location and the demographics of the population being engaged, the priorities might shift. For example, at the Plastic Free July events hosted at the Norfolk Botanical Gardens, most respondents demonstrated an affinity for protecting green spaces. While at the Newport News Transit Center, the majority of participants leaned towards investing in public transit (although it should be noted that this continued to be highly prioritized by the public). The CCAP Engagement team noted that for future engagements, location and sentiment could possibly be additional factors to track.

A Vast MSA

One of the biggest challenges to engagement efforts for the CCAP engagement team was the size of the MSA. Within the MSA are 20 different localities, and over 1.8 million people. This made it difficult to determine where to focus engagement efforts (in person outreach, digital ads, mailing postcards, etc.) in a financially sustainably and feasible manner. The team had less engagement with the western and northern areas of the region than initially hoped for. To try and overcome this, the CCAP engagement reached out to PIOs and encouraged them to share the Climate Action Plan and Survey II with their communication channels. A couple of PIOs engaged, and that led to some additional responses. Engaging with the northeastern NC part of the MSA was also difficult due to distance, lack of previously formed relationships, and a lack of familiarity with engagement best practices for the area.

More Engagement, Sooner

Based on the lessons learned above, the CCAP Engagement team would recommend doing additional outreach in more locations, sooner to better socialize the plan and get more feedback from the public.

Survey Platforms

There were several complaints about the ArcGIS Survey123 platform and the ranking tool. Due to responses about being unable to rank actions, the team added an open-ended feature and adjusted Survey II to notate the issue. In the future, the team may avoid using this functionality on surveys to avoid respondent drop off and frustration.

Appendix E. Consumer Costs for Home Upgrades and EVs in Virginia

Installing rooftop solar, efficient electric HVAC systems, and switching to an electric vehicle (EV) are key actions residents and businesses can implement from the plan that would help significantly reduce emissions across the state. These actions also support lower energy bills, can provide energy resilience and independence, and improve indoor and outdoor air quality. Rooftop solar, heat pumps, and EVs are increasingly cost-competitive and can provide meaningful long-term savings, particularly when paired with available federal, state, and utility incentives.

The section below presents typical costs and savings from these upgrades to help residents make informed decisions. Actual costs and savings will vary based on a range of factors, including equipment type, household energy use, energy bill rates, home characteristics, driving patterns, and incentive eligibility.

Rooftop Solar

- Typical upfront cost (7 kW system): $17,500–$21,000 before incentives
- Estimated lifetime savings over 25 years: $10,000–$24,000

Heat Pump HVAC Systems

- Typical upfront cost: $10,000–$17,000 before incentives
- Incentives: up to $8,000 in federal rebates may be available
- Estimated lifetime savings over 15 years:
  - $5,400 for customers switching from gas furnace and central AC
  - $24,200 for customers switching from electric resistance and central AC

Electric Vehicles & Home Charging

- Typical upfront cost: $40,000 plus $1,200 for home-charger installation
- Typical first year operating costs: $7,200
- Estimated lifetime savings over 15 years: $14,700 for customers switching from a comparable gasoline vehicle

Example Actions for Community Members

Rooftop Solar
For a typical single-family home in Virginia, installing a 7 kW rooftop solar system costs between $17,500–$21,000 before incentives. While this estimate assumes no federal tax credit, some homeowners may qualify for local government or utility programs that can help reduce upfront costs.

Once installed, rooftop solar can significantly reduce monthly electricity bills. A 7 kW system can generate most or all of a typical home's annual electricity needs, depending on household energy use, roof orientation, and shading. Many Virginia households experience a simple payback period of approximately 10–15 years, with continued energy bill savings over the remaining life of the system.

Over a 25-year system lifetime, total savings from reduced electricity costs can range from $10,000–$24,000, depending on system performance, retail electricity rates, and household usage. Actual costs and savings will vary based on roof conditions, system size, equipment selected, electricity use, and available incentives, but rooftop solar remains a strong long-term investment for many Virginia households.

Heat Pump HVAC
For a typical single-family home in Virginia, installing a standard ducted air-source heat pump costs between $10,000–$17,000. Once the federal Home Energy Rebate Program (HEAR) becomes available, eligible households can receive up to $8,000 in rebates to help offset upfront costs. Additional incentives may also be available through local governments and utility programs. Virginia residents can visit energy.virginia.gov for more information on available resources and incentives.

Heat pumps are significantly more efficient than gas furnaces and electric-resistance heating and can reduce heating and cooling bills over time. In Virginia, households switching from electric-resistance heat with central AC are expected to save around $1,200 per year on heating and cooling costs. Even without incentives, these bill savings help offset installation expenses, with a typical payback period of 5–10 years for households transitioning from electric-resistance systems.

Over a 15-year system life, the total cost of purchasing and operating a heat pump is estimated at $19,500–$25,500. With an $8,000 HEAR incentive, households switching to heat pumps can achieve substantial lifetime savings — up to $5,400 for gas-heated homes and $24,200 for homes using electric-resistance heating.

Actual installation costs will vary depending on the type of equipment installed, the condition of the home and existing ductwork, and whether electrical upgrades are needed. Energy costs and savings will also depend on energy use patterns, and utility rates.

Electric Vehicle & Charger
Over a 15-year vehicle life and 180,000 miles, the total lifetime cost of owning and operating an EV is estimated at $70,000 (including purchase, home charger, fuel, and maintenance), compared with roughly $84,700 for a comparable gasoline vehicle. On average, households that switch to an EV can save around $14,700 over the vehicle's lifetime, with higher savings for drivers with greater annual mileage or access to low-cost home charging.

A new passenger electric vehicle generally costs about $40,000, with an additional $1,200 for home-charger equipment and installation. By comparison, a similar gasoline vehicle typically costs around $23,500. While the upfront cost of an EV may be higher, EVs generally have substantially lower fuel and maintenance costs. Based on current Virginia gasoline and electricity prices, EV charging costs average $0.04 per mile, compared with $0.15 per mile for gasoline vehicles (assuming $3.00/gallon and 21 mpg). These savings help offset the higher upfront price, with a typical payback period of approximately 5–10 years, depending on annual mileage, electricity rates, charging access, and available incentives.

Data Sources and Assumptions

Rooftop Solar

- Residential rooftop solar system sized at 7 kW
- Installed cost between $2.5-$3 per watt
- No tax credits or incentives applied
- 25-year system lifetime
- 15%-20% capacity factor
- Average 2024 residential electricity price in Virginia (EIA); growth rates based on trends from AEO 2025

Heat Pump HVAC

- Upfront Costs
  - Heat pump upfront costs (NESCAUM): $10,361-$14,070
  - Gas furnace upfront cost (NESCAUM/RMI): $3,300-$6,400
  - Electric resistance furnace upfront cost (RMI): $4,600
  - Central AC upfront cost (NESCAUM/RMI): $3,300-$6,000
  - Rebate
- Operating Costs
  - Average 2024 residential electricity price in Virginia (EIA); growth rates based on trends from AEO 2025
  - Average 2024 residential natural gas price in Virginia (EIA); growth rates based on trends from AEO 2025

Vehicle and Charger Characteristics

- New battery-electric vehicle (EV) purchase price: $40,000
- Comparable gasoline vehicle purchase price: $23,500
- Vehicle lifespan: 15 years
- Annual mileage: 12,000 miles
- Total lifetime mileage: 180,000 miles
- Level 2 home charger equipment + installation: $1,200

Vehicle Operating Costs

- Electricity cost: EV charging assumed at $0.13/kWh (consistent with recent Virginia residential retail rates)
- EV efficiency: 0.3 kWh per mile (~3.3 mi/kWh)
- EV fuel cost: $0.04 per mile
- Gasoline price: $3.00 per gallon
- Gasoline vehicle fuel economy: 21 miles per gallon
- Gasoline fuel cost: $0.15 per mile
- EV maintenance cost: $0.12 per mile
- Gasoline vehicle maintenance cost: $0.19 per mile