

Pathways to the Future

AIR QUALITY



Comprehensive
Climate Action Plan for
the Richmond region

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Acronyms and Abbreviations

AEO	Annual Energy Outlook
AFV	Alternative fueled vehicle
BAU	Business-as-usual
BEV	Battery electric vehicle
BIPOC	Black, Indigenous, and People of Color
CAC	Climate action committee
CBO	Community-based organizations
CCAP	Comprehensive Climate Action Plan
CMAQ	Congestion Mitigation and Air Quality
CPRG	Climate Pollution Reduction Grant
DER	Distributed Energy Resources
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	Electric vehicle
EWG	Equity Working Group
FCEV	Fuel cell electric vehicle
FHWA	Federal Highway Administration
FLIGHT	Facility-Level Information on Greenhouse gases Tool
FTA	Federal Transit Administration
HUD	Housing and Urban Development
GHG	Greenhouse gas
ICEV	Internal combustion engine vehicle
IRA	Inflation Reduction Act
IRS	Internal Revenue Service
LDV	Light-duty vehicle

LMOP	Landfill Methane Outreach Program
MHDV	Medium and heavy-duty vehicles
MSA	Metropolitan Statistical Area
MSW	Municipal solid waste
NAPEE	National Action Plan for Energy Efficiency
NGO	Non-governmental organizations
NOAA	National Oceanic and Atmospheric Administration
NREL	National Renewable Energy Laboratory
PCAP	Priority Climate Action Plan
PHEV	Plug-in hybrid electric vehicle
PPA	Power purchase agreements
SIT	State Inventory Tool
STBG	Surface Transportation Block Grant
TA	Transportation Alternatives
TPO	Transportation Planning Organization
VMT	Vehicle miles traveled
WARM	Waste Reduction Model
WMP	Waste management plan
ZEV	Zero-emission vehicles

Definitions

Greenhouse Gas (GHG)	The air pollutants carbon dioxide (CO ₂), hydrofluorocarbons (HFCs), methane (CH ₄), nitrous oxide (N ₂ O), perfluorocarbons (PFCs), and sulfur hexafluoride (SF ₆). While some GHGs are naturally occurring, they are considered pollutants when in excessive quantity and when they come from anthropogenic (human-caused) sources.
GHG Inventory	A list of emission sources and sinks and the associated emissions quantified using standard methods.
GHG Reduction Measure	Policies, programs, actions, or projects that reduce GHG emissions or enhance carbon removal. Measures that enhance carbon removal are those that increase the uptake of carbon dioxide from the atmosphere (see Sequestration).
Co-Benefits	Positive effects beyond the stated goal of a GHG reduction measure (e.g., improved public health outcomes, economic benefits, increased climate resilience).
Carbon Dioxide Equivalent (CO₂e)	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.
Carbon Sink	A natural or artificial reservoir that removes and stores carbon dioxide, preventing it from entering the atmosphere as a pollutant. Examples of carbon sinks included soils, oceans, and woody vegetation.
Distributed Energy	Decentralized sources of electricity production, typically from many small producers instead of large, utility-scale power plants. Ex: solar panels on households
Embodied Carbon	Emissions from the entire lifecycle of a product, from raw material extraction to manufacturing, transportation, maintenance, and disposal. Every product has embodied carbon, but efficiency improvements at any lifecycle stage can reduce the amount of emissions associated with the product.
Metric Ton (MT)	1 metric ton = 1,000 kilograms. That's about 2,205 pounds or 1.1 US tons (also known as short tons).
Micro-Transit	Flexible, on-demand transportation service that uses smaller vehicles to provide shared rides along dynamic routes.
Sequestration	The process by which carbon dioxide is pulled out of the atmosphere and stored (see Carbon Sink). An example of natural sequestration is the uptake of carbon by vegetation and subsequent storage in soils and plant tissues.

Acknowledgements

Guided by our member local governments, PlanRVA facilitates the Richmond region's physical, social, and economic development through holistic and coordinated planning and regional projects, strategic partnerships, and technical support for local initiatives. We actively engage representatives from government, the private and not-for-profit sectors, civic and community-based organizations, and the public to address critical regional issues. PlanRVA developed the Pathways to the Future: Air Quality Plan with grant funding from the U.S. Environmental Protection Agency (EPA) Climate Pollution Reduction Grant (CPRG) program to serve as a comprehensive climate action plan for the region. This plan has been developed over two years, led by PlanRVA staff, supported by the contracting firm, ICF, and with input from localities, residents, and stakeholders across the Richmond Metropolitan Statistical Area (MSA).

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The team also appreciates the many individuals and organizations who contributed project ideas, attended meetings, or otherwise supported the planning process, including:

Virginia Department of Environmental Quality (DEQ)

Richmond Regional Transportation Planning Organization (RRTPO)

Tri-Cities Metropolitan Planning Organization (MPO)

Central Virginia Transportation Authority (CVTA)

Central Virginia Waste Management Authority (CVWMA)

PlanRVA also expresses its sincere gratitude to its community members and the multiple other stakeholders across the Richmond MSA that contributed to this process.

Disclaimer: This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement 95317301 to Richmond Regional Planning District Commission ("PlanRVA"). The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

Introduction



Introduction

The *Pathways to the Future: Air Quality* Plan is the first regional approach to climate action planning in central Virginia. This plan reflects two years of collaboration between localities in the Richmond metropolitan statistical area (MSA), with significant input from private stakeholders, nonprofit and community-based organizations, and the public. It charts a path towards a clean energy economy for the MSA's 18 localities and 5 Indigenous nations - envisioning a future with better air quality, better health outcomes, and a strong and diverse economy. This vision will be co-created; each community can identify the pieces of the puzzle they will contribute, and we will work together towards the shared goals set forth in this plan.

The Air Quality Plan 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. Parallel plans are being developed by Hampton Roads PDC, Metro-Washington Council of Governments, and Virginia Department of Environmental Quality, all supported through the same federal grant program. Once completed, every locality in the state will be covered by a plan.

Through the lens of PlanRVA's regional planning portfolio, the Air Quality Plan is part of a set of core regional topical plans which make up the [2025-2030 Regional Strategic Plan: Pathways to the Future](#)¹. The Regional Strategic Plan includes the Long-Range Transportation Plan, the Richmond-Crater Multi-Regional Hazard Mitigation Plan, the Comprehensive Economic Development Strategy (CEDS), and the Natural Resources Plan. Together, these plans advance PlanRVA's Strategic Vision: Strategic and Resilient Infrastructure, a Healthy Environment, Attainable Housing, a Strong Economy, and Opportunity and Choice for Everyone.

After PlanRVA, the Crater Planning District has the most localities covered by the Air Quality Plan, and their participation was essential to ensuring that the plan reflects priorities across jurisdictional boundaries. Crater's input helps situate this plan within their own body of work, including Plan2045, the Long-Range Transportation Plan; the forthcoming Crater Regional Resilience Plan; and the [2023–2028 Crater Region CEDS](#), which emphasizes connectivity, quality of life, and sustainable economic growth.

The Pathways to the Future: Air Quality Plan has been a data-driven, collaborative process, and an opportunity to consider aspirations for the future. The following pages offer a framework for localities in the Richmond MSA to work collaboratively to address climate change and air pollution.

Purpose and Scope

Authorized by Congress under the Inflation Reduction Act (2022), the Climate Pollution Reduction Grant provided first-of-its-kind funding for states, local governments, Indigenous nations and territories to develop plans for reducing greenhouse gas emissions and other harmful air pollution. PlanRVA provided leadership and coordination to ensure that the project delivered real benefits to our communities. When

¹ <https://planrva.org/home/about-the-commission/regional-strategic-plan/>

we come together to set a regional vision and chart evidence-based, actionable steps, we maximize the impact of these funds and create momentum that drives long-term success.

The goal of the Pathways to the Future: Air Quality Plan is to guide localities, Indigenous nations, agencies, industry, and communities to work together to reduce emissions, improve local air quality, support clean energy workforce development, and ensure a just and equitable energy transition in vulnerable communities. This plan reflects significant input from the community.

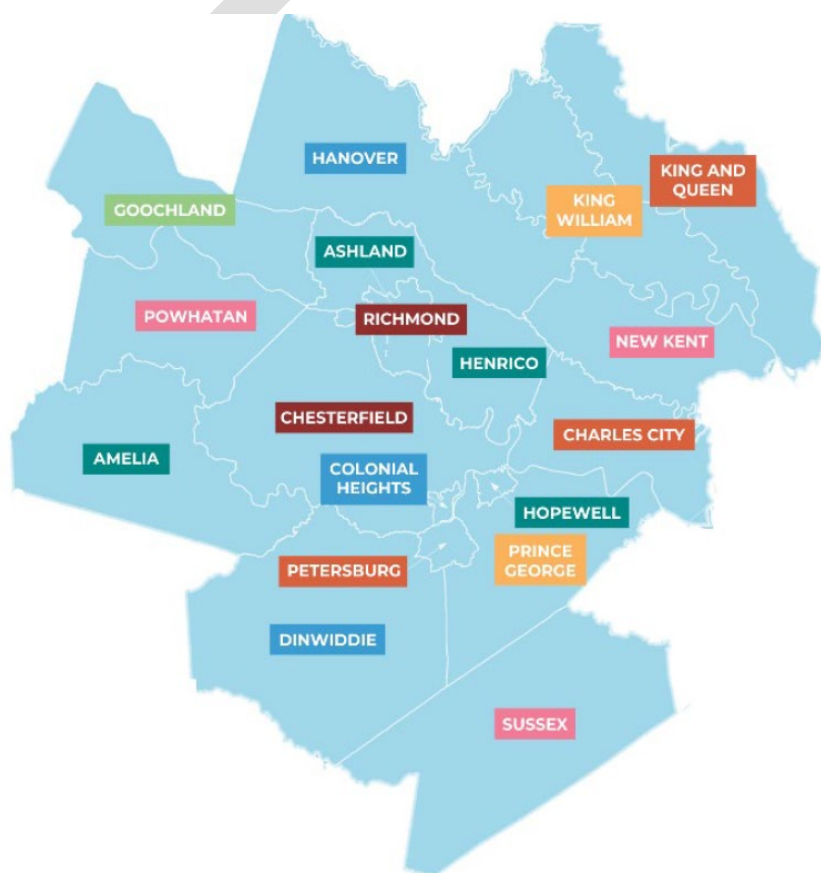
This plan covers the full Richmond Metropolitan Statistical Area (MSA), covering 13 counties and 5 independent cities and towns. It also belongs to the 5 sovereign Indigenous nations of the region: The Chickahominy Indian Tribe, the Chickahominy Indian Tribe-Eastern Division, the Pamunkey Indian Tribe, the Rappahannock Indian Tribe, and the Upper Mattaponi Indian Tribe.

The plan includes data on greenhouse gases (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 co-benefits and workforce considerations for implementing the identified measures.

The plan includes a total of 22 measures across six sectors:

- **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.
- **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 can help reduce pollution.
- **Natural and Working Lands (NWL):** Conserving, restoring, and managing lands to preserve and enhance their benefits – such as forest preservation and increased tree canopy – can support GHG reductions and enhance community resilience. Also includes managing lands used for agricultural activities, including growing crops and livestock grazing.
- **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.
- **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.

Figure 1. Richmond Metropolitan Statistical Area (MSA)



How To Read This Report: Key Terms

What Are Greenhouse Gases?

Invisible gases are released into the air through industrial and natural processes and when burning fossil fuels, such as from driving cars, heating buildings, producing electricity, and farming. 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 (CO₂) – from burning fossil fuels like coal, oil, and gas
2. Methane (CH₄) – from landfills, livestock, and natural gas systems
3. Nitrous oxide (N₂O) – from fertilizers, farming, and some industrial processes
4. Hydrofluorocarbons (HFCs) – used in refrigeration and air conditioning
5. Perfluorocarbons (PFCs) – from aluminum production and electronics manufacturing
6. Sulfur hexafluoride (SF₆) – used as an insulating gas in electrical equipment

What does “CO₂ 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 CO₂e. CO₂e is a common unit that expresses the warming impact of any greenhouse gas in terms of how much carbon dioxide (CO₂) 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.

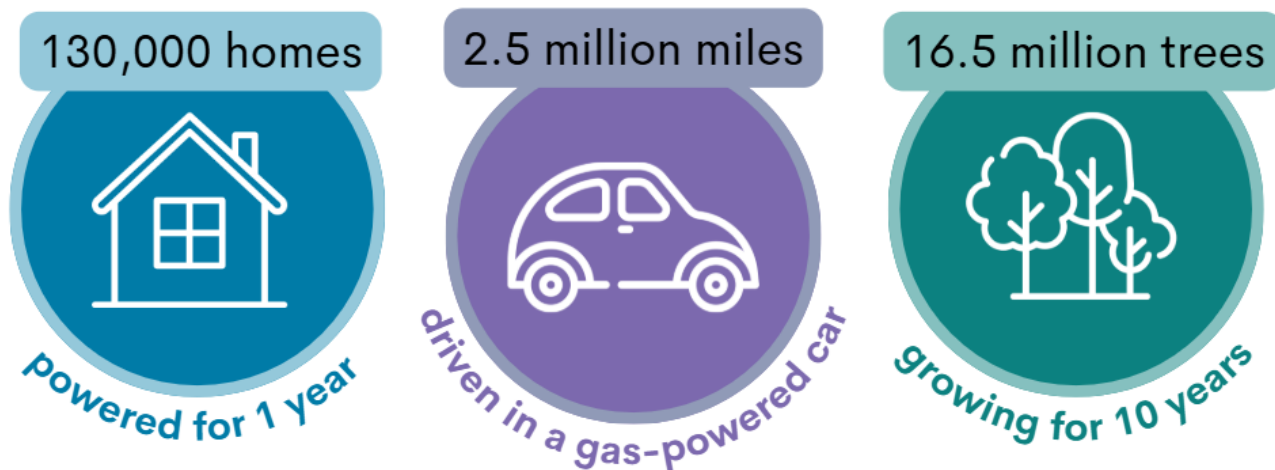
For example, 1 ton of methane (CH₄) warms the planet 28 times more than 1 ton of CO₂ over 100 years, so 1 ton of methane is equivalent to 28 tons CO₂e.

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

What is equivalent to 1 million metric tons of CO₂ (MMT CO₂e)?



What is carbon sequestration?

- **Sequestration is the process of capturing carbon dioxide from the atmosphere (or from emission sources) and storing it so that it doesn't contribute to climate change. The goal of increasing sequestration is to reduce the amount of CO₂ in the atmosphere, helping slow down climate change. There are two main types:**
 - **Natural sequestration:** Forests and soil naturally absorb CO₂. For example, trees take in CO₂ during photosynthesis.
 - **Technological sequestration:** Methods that capture CO₂ 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 CO₂ 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 reflect 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.**

Scope 1, 2, and 3 GHG Emissions Reporting

Scopes are a way to categorize GHG emissions based on where they come from and who controls them. They are a standard reporting structure used in GHG inventories to help entities understand and track emissions. This report primarily focuses on Scope 1 and 2 emissions in the Richmond MSA.



Scope 1 (Burn): Direct emissions from *burning* fuel — like in vehicles or gas furnaces for building heating systems.

Scope 2 (Buy): Indirect emissions from the electricity we *buy*, representing the carbon intensity of the resources used to produce it.

Scope 3 (Beyond): Indirect emissions that go *beyond* our operations, also called “upstream” emissions.

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

When we reduce 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 cut 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.

Regional Emissions Inventory

Emissions inventories help to inform which sectors should be prioritized during GHG reduction planning. The inventory was compiled for 2022 – our ‘baseline’ year - and assesses GHG sources and sinks across six key sectors: transportation, residential and commercial buildings, electric power use, industry, solid waste and wastewater, and natural & working lands.

GHG inventories are complex and imperfect. However, they arm us with information on the greatest sources of air pollution and allow us to track progress.

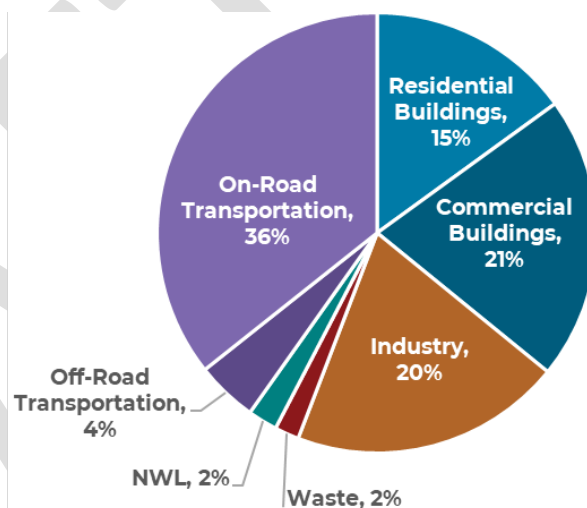
2022 GHG Summary

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 industry sector includes both energy use in industrial buildings and emissions associated with industrial processes.

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, such as the carbon stored in forests and wetlands. Total gross emissions in 2022 were 22.3 MMTCO₂e. When accounting for the value of carbon stored in regional sinks, total emissions decline to 17.2 MMTCO₂e, with over 5 MMTCO₂e being stored in regional natural lands – primarily forests and urban trees.

Within the region, emissions vary largely across localities. Those with large populations and commercial or industrial activities produce higher levels of emissions. Less densely populated areas may also benefit from greater carbon sinks due to forest or grasslands. The highest emitting localities in the region are Chesterfield, Henrico, Hanover, and Richmond, all of which are centers of population and economic

Figure 2. Richmond MSA Gross Consumption-Based (Scope 1 & 2) GHG Inventory, 2022



Key Findings

- Total gross emissions in 2022 were 22.3 MMTCO₂e, and total net emissions were 17.2 MMTCO₂e.
- The largest sources of emissions are on-road transportation, buildings, and industry.
- The largest categories of CO₂ sink in the region from natural lands are forest (~4.6 MMTCO₂e sequestered) and urban trees (~0.4 MMTCO₂e, sequestered). The region's natural lands are key to help offset emission sources and also provide significant health and climate resilience

activity. Chesterfield, Dinwiddie, Sussex, and Hanover have the highest value of carbon sinks from natural lands.

Co-Pollutant Inventory

There are many more air pollutants that impact public health than the six greenhouse gases tracked in the inventory above. Criteria air pollutants (CAPs), are a class of pollutants that harm public health and the environment, and hazardous air pollutants (HAPs), are known to cause cancer and other serious health impacts. CAP and HAP emissions generally accompany greenhouse gas emissions. Reducing GHGs therefore also reduces CAPs and HAPs. 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.

- Criteria Air Pollutants (CAPs) include ozone, particulate matter (PM_{2.5}, PM₁₀), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and lead.
- Hazardous Air Pollutants (HAPs), also known as air toxics, include over 180 chemicals such as benzene and mercury.

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 use in agricultural activities, paints, varnishes, cleaning supplies, gasoline and 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 (NH₃) contributes to the formation of PM_{2.5}, a CAP, when it reacts with other pollutants like NO_x and SO₂.

Table 1 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 1. Richmond MSA Co-Pollutant Emissions (Metric Tons), 2022

Category	CO	NO _x	VOC	PM ₁₀	PM _{2.5}	SO ₂	NH ₃
Agriculture	19,362	1,424	96,523	3,987	2,146	121	3,496
Industrial Processes	2,640	2,545	11,967	7,098	1,922	757	638
Transportation	101,098	10,746	6,609	940	488	64	818
Buildings	15,113	6,772	1,985	4,055	3,791	482	416
Waste	8,629	409	1,492	1,350	1,165	214	595
Other	327	8	83	4,189	772	1	-
Total	147,170	21,902	118,659	21,618	10,285	1,638	5,962

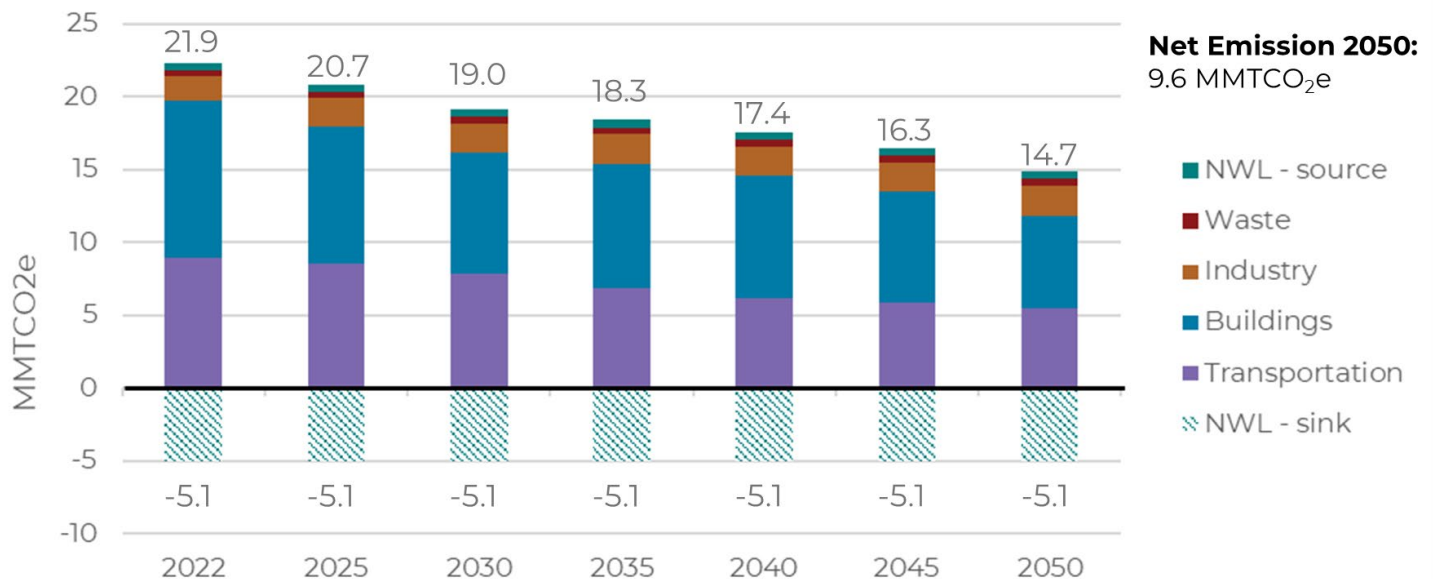
GHG Business as Usual Projections

A business-as-usual (BAU) GHG emission projection scenario illustrates how the region's emissions might look in the future without additional action. The BAU scenario reflects future emissions under state and federal policies in place at the time of writing this report. It also considers historical trendlines and expected growth factors such as changes in population and employment. The BAU scenario serves as a basis against which we can compare emission reduction benefits from implementation of possible GHG reduction measures.

Figure 3 shows the region's GHG emission projections by sector. Compared to the 2022 inventory base year, the BAU forecasts that net GHG emissions will decline 22% by 2035, and 43% by 2050. The transformative impact of the Virginia Clean Economy Act (VCEA) is a primary driver of the emissions reductions in this scenario. The VCEA shifts the source of electricity on the grid away from fossil fuels which means that increased electrification in the transportation and buildings sectors reduces overall emissions, instead of just shifting emissions to the power generation sector.

The Richmond MSA should aim to keep pace with the BAU projections through 2035. Achieving a 22% decrease in emissions within 10 years will be important for setting the region up for success in the long term. It's important to remember that *any amount of GHG reduction is valuable and reaps benefits to our communities.*

Figure 3. Richmond MSA GHG Emissions by Sector: Business-as-Usual Scenario



Key Findings

- By 2050, transportation sector emissions are projected to decline 38% from 2022 levels driven by improved vehicle fuel efficiency and increased electric vehicle adoption.
- By 2050, building sector emissions are expected to decline by over 40% from 2022 levels. These reductions are largely driven by state mandates for a net zero emissions electric power sector by 2050. Through 2050, the BAU assumes a cleaner electricity generation mix, which leads to lower emissions associated with electricity use in buildings. In addition to the cleaner electricity mix,

ongoing trends towards more energy efficient building appliances and equipment drive emission reductions.

- **Emissions from the waste sector are projected to rise slightly as population growth increases overall waste generation.**
- **Emission from the industrial sector are projected to rise slightly as well based on increased economic employment projections.**
- **For the NWL 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.**

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GHG Measures



Identified GHG Reduction Measures

This section presents a menu of GHG reduction measures designed to guide action across the region. The measures reflect a broad range of strategies—some ready for immediate implementation, others requiring further exploration or collaboration. 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.

Table 2. List of GHG Reduction Measures

#	Measure Description	Sector
B1	Invest in energy efficiency, electrification, and other improvements for municipal and school buildings.	Buildings
B2	Increase resident education and awareness of utility, state, and federal incentives for energy efficiency home improvements and electric appliances.	Buildings
B3	Increase energy efficiency in existing commercial and industrial buildings through financial incentives and educational outreach programs.	Buildings
B4	encourage the design, building, and operation of residential, commercial, and industrial buildings above the current required code.	Buildings
E1	Support the adoption of distributed renewable energy resources.	Energy
E2	Support the development of grid-scale clean energy development and utility efforts to enhance grid resiliency.	Energy
I1	Support local production and use of low-embodied carbon materials through clean procurement frameworks.	Industry
I2	Support emissions reductions from industrial processes.	Industry
NWL1	Remove carbon through nature-based solutions, including preserving existing natural working lands and proactively managing land use changes.	Natural & Working Lands
NWL2	Support and incentivize shared land use with renewable energy and agricultural activities.	Natural & Working Lands
NWL3	Expand urban agriculture and develop region-wide and inter-regional food system distribution.	Natural & Working Lands
NWL4	Increase equitable tree canopy coverage and access to public green spaces.	Natural & Working Lands

#	Measure Description	Sector
NWL5	Increase soil conservation and nutrient management practices in agriculture.	Natural & Working Lands
NWL6	Support livestock management strategies that reduce emissions.	Natural & Working Lands
T1	Reduce emissions from port operations through the adoption of low-carbon fuels, electric equipment, and operational changes.	Transportation
T2	Support, incentivize, and provide assistance for the rapid adoption, equitable installation, and use of zero-emission vehicles.	Transportation
T3	Expand equitable transit access.	Transportation
T4	Reduce vehicle miles traveled through micromobility options and micro modal infrastructure.	Transportation
T5	Expand use of low-carbon transportation materials	Transportation
W1	Decrease amount of waste sent to landfills.	Solid Waste and Wastewater
W2	Support a local, circular economy.	Solid Waste and Wastewater
W3	Support efficiency upgrades at wastewater treatment plants.	Solid Waste and Wastewater

Authority to Implement

To effectively address these measures, it is crucial for public and private partners to collaborate closely. The Air Quality Plan is a community-based effort that relies on the active participation and cooperation of local governments, businesses, non-governmental organizations, and residents. By working together, the greater Richmond region can implement innovative solutions, share resources, and create a resilient and sustainable future for the region.

Natural & Working Lands

Local governments have primary authority over land use, zoning, and conservation, allowing them to implement projects that protect public health, natural resources, and community well-being. This includes initiatives like agrivoltaics, pollinator-friendly solar, and shared land use projects, which may require approval from local legislative or administrative bodies, particularly when public funding or zoning changes are involved. Coordination with state agencies is necessary when projects affect state-managed lands or require technical or regulatory support. Local governments, along with agricultural agencies and conservation districts, also play a key role in advancing local food systems, urban agriculture, and farm-to-school programs, often in collaboration with elected officials and community partners.

Transportation

Local governments have the authority to procure vehicles for public fleets and can support emissions reductions by adopting low- and zero-emission vehicle procurement policies within the requirements of the Virginia Public Procurement Act. While private vehicle choices are not regulated at the local level, local jurisdictions can influence adoption through zoning, building codes, and policies that support EV charging infrastructure. Actions related to public transit systems may require coordination and approval from regional or state transportation agencies, depending on ownership and governance structures. Localities also have the ability to expand pedestrian and bicycle infrastructure by updating zoning codes, transportation plans, and street design standards. Additionally, employers can contribute by implementing telework policies and encouraging transit use, often supported by local or regional programs.

Waste

County government agencies, in partnership with regional waste authorities, private utilities, landfills, and composting facilities, have the authority to implement waste management projects. Local governments play a central role in managing solid waste and wastewater systems, both of which offer opportunities to reduce greenhouse gas emissions. For solid waste, localities can implement policies and programs that promote diversion from landfills—including recycling, composting, and reuse—to reduce methane emissions from decomposing organic material. While landfills are regulated by the Virginia Department of Environmental Quality (VA DEQ), local governments can support methane capture projects, adopt diversion goals, and work with regional authorities and private haulers to improve waste infrastructure. For wastewater, local utilities and public works departments can reduce emissions through energy efficiency upgrades, methane capture, and improved treatment processes. Coordination with state agencies, especially VA DEQ, is often required for infrastructure improvements, permitting, and funding.

Buildings

Building energy codes in Virginia are established by the Virginia Department of Housing and Community Development (DHCD) and enforced uniformly across the state, and localities cannot mandate stricter energy standards than those set by the state. However, local governments have significant influence over building-related emissions through their authority over zoning, permitting, and municipal building operations. They can implement voluntary programs, demonstration projects, and incentives to encourage energy efficiency and electrification. Local governments can also lead by example by adopting high-performance standards for public buildings. Coordination with state agencies, utilities, and regional energy programs helps scale impact and expand access to technical assistance and incentives.

Industry

In Virginia, the authority to implement emissions reduction activities in the industrial sector rests with the industrial facility owner/operator and federal and state governments. The U.S. Environmental Protection Agency (EPA), VA DEQ, and the Virginia Department of Energy (Virginia Energy) are the primary regulators of this sector. The EPA and VA DEQ regulate air emissions and manage environmental permitting, while Virginia Energy supports industrial decarbonization through energy efficiency programs, technical assistance, and clean energy initiatives. Although local governments have limited regulatory authority over industrial facilities, they can play a supporting role through land

use planning, local incentives, and partnerships with industry to encourage voluntary emissions reductions.

Energy

In Virginia, authority over clean energy deployment is primarily held by state agencies, the State Corporation Commission (SCC), and regulated utilities. Virginia Energy plays a key role in advancing both distributed solar and grid-scale clean energy through policy development, incentive programs, and technical support. The SCC regulates utility planning and approves large-scale energy projects, including renewable energy generation and grid infrastructure. Local governments do not control energy generation but can support deployment by streamlining permitting, updating zoning ordinances, and promoting rooftop solar adoption on public and private buildings. Partnerships with utilities and state agencies can also help bring clean energy projects to the community level.

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**
- **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, and GHG reductions.

Health



Air Quality



Water Quality



Resilience



Habitat



GHG Emissions



- **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. Actions are designated as either near term or visionary. Near term actions utilize proven strategies and technologies that are available today, financially practical, and within local control or influence. Near-term actions will help achieve the plan's 2035 goal. Visionary actions are those that will help the region achieve net zero emissions and may require significant investment or the use of emerging technologies.
- **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.

GHG Reduction Results

Based on the BAU projections and the identified measures, this plan sets a target of achieving a 22% reduction in GHG emissions by 2035 from 2022 levels, and a long-term goal of being on a path to net zero GHG emissions by 2050. 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.

Figure 4 shows the region's GHG emission projections by sector. Compared to the 2022 inventory base year, the pathway achieves a 31% reduction in net emissions by 2035 and a 93% reduction in net emissions by 2050, with just 1.2 MMTCO₂e of net GHG emissions remaining in 2050. While 2050 is the long-term target, the next 10 years are critical. The actions we take in the near term—through 2035—offer significant potential for meaningful emissions reductions and set the foundation for deeper cuts in the decades to follow. This near-term focus emphasizes proven strategies and technologies that are available today, prioritizing those that are technically feasible, financially practical, and within local control or influence. Such actions are highlighted in the following section as a “near term” action, while others are noted as “visionary” and aligned with a pathway to net zero emissions. By highlighting what we can do now, this framing not only illustrates a path to net zero by 2050, it ensures we build momentum with practical actions that position the greater Richmond community for long-term success.

Figure 4. Richmond MSA GHG Emissions by Sector: Net Zero Pathway Scenario

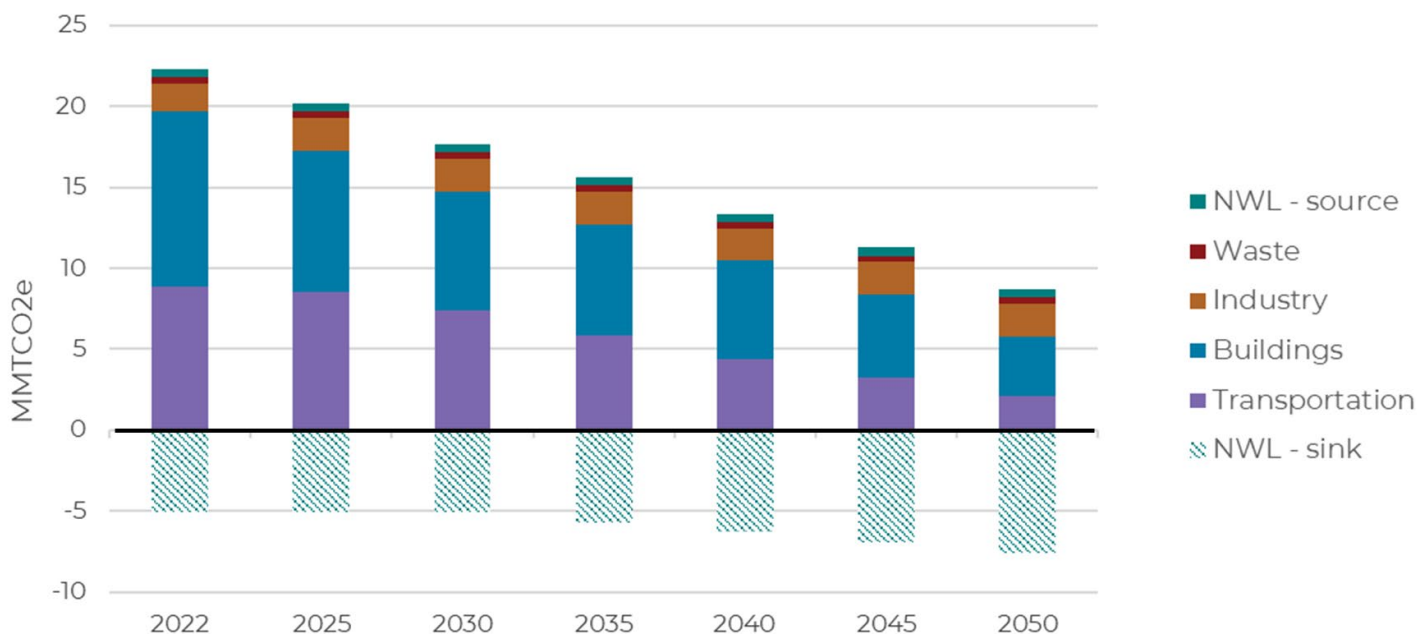


Figure 5 below presents the pathway to net zero scenario via a “wedge chart”, which illustrates the impact on GHG reductions from each measure. The measures driving the largest GHG reductions for this pathway include:

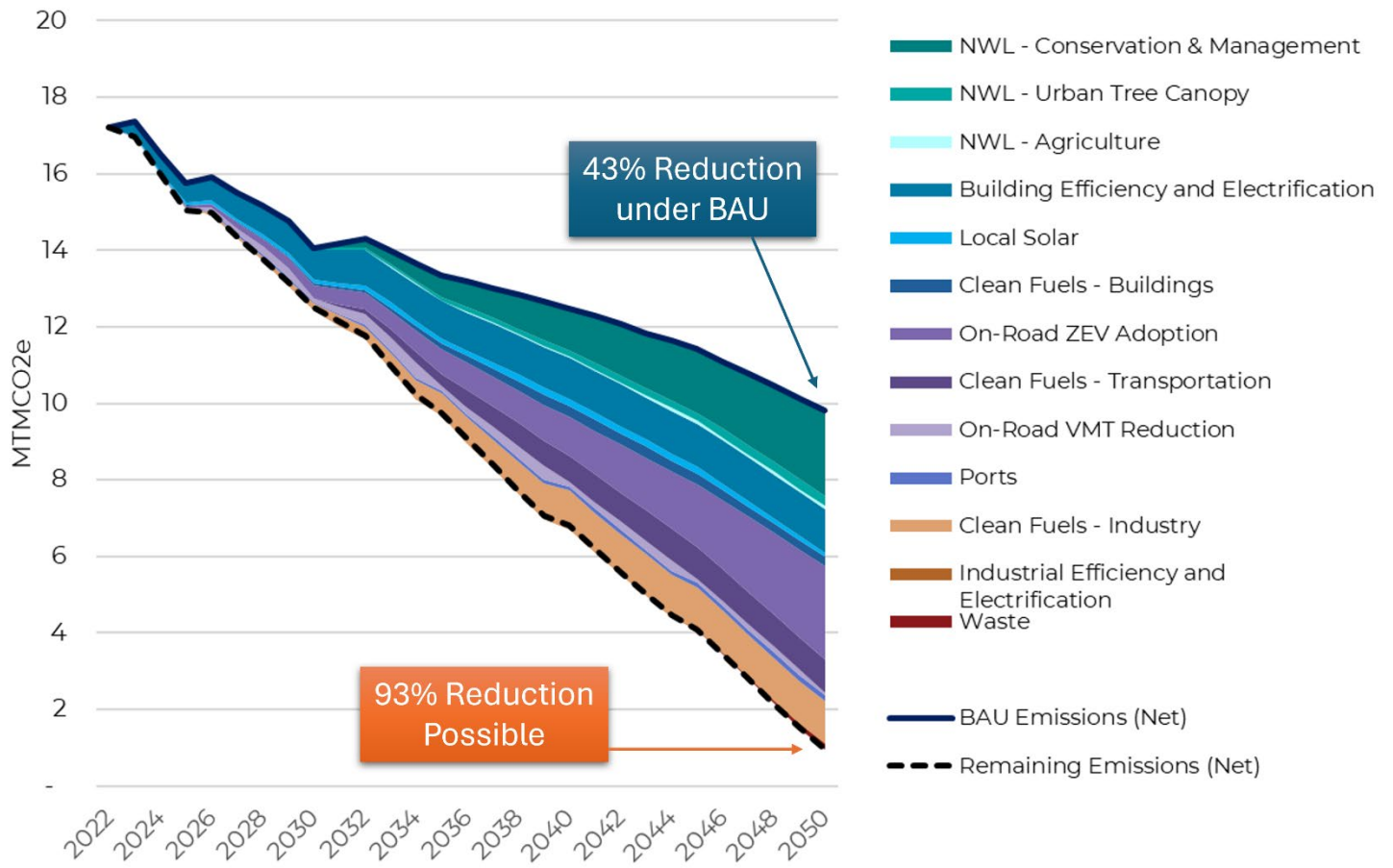
1. **Adoption of zero-emission vehicles. When paired with electricity powered by clean energy (as mandated by the VCEA), this strategy results in the greatest cumulative GHG reductions in the region.**

- 2. Building energy efficiency and electrification of heating, cooking, and home appliances. Similar to transportation, the region's expected clean grid is a key enabling factor for the reductions achieved by this measure.**
- 3. Increased sequestration protecting and restoring wetlands and forest lands.**
- 4. The use of low carbon fuels like hydrogen and renewable natural gas to decarbonize fuel use in industrial facilities.**

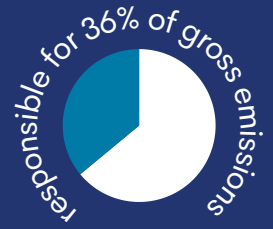
To present GHG reductions by measure, a “wedge chart” may be used in planning efforts to illustrate how different climate mitigation strategies impact GHG emissions over time. Each “wedge” represents a mitigation strategy (e.g., ZEV adoption, urban tree canopy expansion, etc.) tied to the GHG measures list in Table 2. 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 show the emissions under the Net Zero Scenario. The wedges in between represent the various way 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 the plan's goal of net zero GHG emissions by 2050.

In order of magnitude, the transportation, buildings, and NWL sectors are the top three drivers of emission reductions, followed by industry and waste. The state 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 5. Net Zero Scenario: GHG Emission Reductions from Each Measure



BUILDINGS EMISSIONS OVERVIEW



What are the main sources of buildings emissions in Richmond?



RESIDENTIAL BUILDINGS

Responsible for **42%** of building emissions



COMMERCIAL BUILDINGS

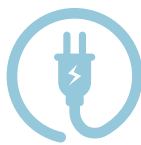
Responsible for **58%** of building emissions.

How do buildings release greenhouse gases?

Buildings emit greenhouse gases through **stationary combustion**, for example through the direct use of natural gas to power home heating systems and stove tops. These systems can accidentally emit greenhouse gases (known as **fugitive emissions**) through leaks or due to inefficiencies. The use of **hydrofluorocarbons** in refrigeration and air conditioning systems contributes to greenhouse gas emissions. Finally, buildings consume **electricity** from the grid, the generation of which releases greenhouse gases.



STATIONARY COMBUSTION



ELECTRICITY



HYDROFLUORO- CARBONS (HFCs)



FUTIGIVE EMISSIONS

How can local players support building decarbonization?



LOCAL GOVERNMENT

Through zoning and benchmarking programs.



BUILDERS & CONTRACTORS

Through procurement and construction practices.

BUILDINGS

MEASURES & PARTNERS

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



Invest in energy efficiency, electrification, and other improvements to achieve net zero operations for **municipal and school buildings**.



Increase resident education and awareness of utility, state, and federal incentives for energy efficiency **home improvements and electric appliances**.



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



Strongly encourage the design, building, and operation of residential, commercial, and industrial buildings **above current required code**.

BUILDINGS SECTOR PARTNERS



Virginia Department of Environmental Quality administers the Home Electrification and Appliance Rebates (HEAR) program.



Virginia Energy collaborates with the Governor's office to develop comprehensive energy plans.



Department of Housing and Community Development administers the Uniform Statewide Building Code (USBC), including energy codes for residential and commercial buildings. They also administer the Weatherization Assistance Program (WAP).

B1. Invest in energy efficiency, electrification, and other improvements to achieve net zero operations for municipal and school buildings.



2025-2050 GHG Reductions:

This measure provides technical and financial assistance to help municipal and school buildings reduce emissions and save money through energy efficiency, electrification, and other clean energy investments. By leading by example with high-performance standards, retrofitting facilities with renewable energy and efficient technologies, and supporting comprehensive building energy management, local governments can reduce GHG emissions, lower utility costs, and improve indoor environments. The measure also strengthens community engagement, expands access to resources and incentives, and encourages broader adoption of sustainable practices across public and private sectors. This measure is most appropriate for localities and school districts.

Measure Goals and Outcomes

Category	Outcome
Energy and Cost Savings	Reduced energy use and associated costs
GHG Emissions	Lower GHG emissions from building operations
Indoor Environment	Improved indoor air quality and thermal comfort

Key Actions

Lead by example in facility efficiency and electrification to encourage residential and commercial building owners to make upgrades to their buildings:

- **NEAR-TERM** Meet statewide High-Performance Buildings Act requirements to ensure new and renovated public buildings meet efficiency requirements. Ensure all new government buildings meet LEED standards or similar (e.g., Living Building, Earthcraft, etc.), following the successful implementations in Henrico and Chesterfield Counties. Key Actors: Localities
- **VISIONARY** Develop building energy performance standards and best practices for all public facilities. Track energy and emissions to inform project selection to cost-effectively reduce emissions. Key Actors: Localities

Enhance Public Facilities:

- **NEAR-TERM** Retrofit public buildings with solar panels and EV charging stations, prioritizing more affordable on-site solar installations that do not trigger expensive grid upgrade requirements. Key Actors: Localities
- **NEAR-TERM** Audit existing public buildings to identify potential efficiency upgrades Key Actors: Localities,
- **NEAR-TERM** Transition to LEDs and in streetlights, government facilities, and schools. Install motion-sensors. Key Actors: Localities

- **VISIONARY** Include considerations for embodied carbon when designing new municipal or school facilities. Key Actors: Localities

Improve community engagement and regulatory capacity:

- **NEAR-TERM** Improve information sharing to ensure local governments are aware of resources available. Key Actors: Localities, regional organizations
- **NEAR-TERM** Develop or clarify zoning to allow for more EV charging facilities. Key Actors: Localities

Provide financial incentives:

- **VISIONARY** Establish a revolving green fund² for energy and water efficiency projects, leveraging resources like DOE's Loan Program Office and similar programs at the state level Key Actors: Localities
- **NEAR-TERM** Consider energy saving performance contracting (ESCO) options leveraging information and resources provided by Virginia Energy³. Key Actors: Localities

Possible Output Metrics

Metric
Number of LEED-certified, Living Building, or other certifications for local government and school buildings
Number of buildings that are all-electric, net zero, or meet passive house standards
Number of schools and local government buildings that participated in incentive programs for building energy efficiency or electrification
Number of heat pumps installed
Number of efficient gas and electric HVAC systems installed
Number of projects that paired building upgrades with EV infrastructure installation or onsite solar

² § 15.2-958.3:1. Local green banks - <https://law.lis.virginia.gov/vacode/title15.2/chapter9/section15.2-958.3:1/>

³ <https://energy.virginia.gov/energy-efficiency/performancecontracting.shtml>

B2. Increase resident education and awareness of utility, state, and federal incentives for energy efficiency home improvements and electric appliances.



2025-2050 GHG reductions:
13.4 MMTCO₂e

This measure aims to empower residents to make informed decisions about energy efficiency and electrification by increasing education and awareness of available utility, state, and federal incentives for home improvements and electric appliances. Through accessible cost-benefit comparisons, support for community-scale aggregation programs like Solarize, prioritization of weatherization, and funding for home energy audits, the goal of this measure is to help households understand their options, reduce energy use, and lower utility bills. By making information and resources more widely available, the measure supports equitable access to clean energy upgrades and encourages broader participation in the transition to efficient, all-electric homes. This measure is most appropriate for non-profits, private businesses, utilities, regional entities, localities, and state agencies.

Measure Goals and Outcomes

Category	Outcome
Resident Awareness	Increased resident awareness of utility, state, and federal incentives
Home Health	Improved thermal comfort and air quality
Utility Bills	Lower utility bills

Key Actions

- **NEAR-TERM** Create cost/benefit comparisons between existing gas/oil heating and cooling and electric heating and cooling Key Actors: regional organizations, non-profits, state, localities
- **NEAR-TERM** Support community-scale aggregation programs, such as Solarize. Key Actors: Localities, regional entities, non-profits
- **NEAR-TERM** Prioritize weatherization before installation of electrification measures. Key Actors: Localities, private businesses, non-profits, regional entities
- **NEAR-TERM** Provide funding for low- to no-cost home energy audits. Key Actors: non-profits, localities, state agencies
- **NEAR-TERM** Develop and distribute user-friendly guides or toolkits explaining available incentives, eligibility, and application processes tailored for homeowners, renters, and landlords. Key Actors: Private businesses, localities, regional entities, non-profits
- **NEAR-TERM** Host in-person or virtual webinars or workshops to walk residents through the benefits of energy efficiency, electrification, and how to access incentives. Key Actors: Localities, regional entities, non-profits, private businesses
-

- **NEAR-TERM** Establish partnerships with utilities to include energy efficiency information in monthly bills or through targeted communications. Key Actors: Localities

Possible Output Metrics

Metric
Number of households served by community-scale aggregation programs
Number of low- to no-cost home energy audits funded
Number of residents reached through outreach campaigns

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



**2025-2050 GHG reductions:
10.1 MMTCO₂e**

programs.

This measure aims to increase energy efficiency in existing commercial and industrial buildings by offering financial incentives and educational outreach programs. Providing funding, technical assistance, and support for clean energy lending helps building owners, especially in underserved markets, overcome barriers to upgrading their facilities. Outreach efforts and partnerships with community organizations and utilities ensure that building owners and managers are aware of available resources, best practices, and incentive programs, making it easier to implement energy-saving improvements and reduce emissions. **Note - the emissions from industrial buildings are included in the Industry sector, not the Buildings sector. This measure is cross-cutting.* This measure is most appropriate for state agencies, localities, private businesses, and non-profits.

Measure Goals and Outcomes

Category	Outcome
Energy Use and Costs	Reduced energy use and operating costs
GHG Emissions	Lower GHG emissions
Building Comfort	Improved building comfort

Key Actions

Provide funding and technical assistance

- **VISIONARY** Provide funding and technical assistance to building owners for scoping projects and combine multiple sources of funding to pay for building upgrades. Prioritize underserved markets. Key Actors: Non-profits, localities, state agencies
- **NEAR-TERM** Leverage clean energy lending programs, such as C-PACE.
- **NEAR-TERM** Promote available state and federal incentive and grant opportunities. Provide technical assistance to public entities, businesses, and individuals on how to qualify and utilize them. Key Actors: Localities, regional entities, non-profits, state agencies
- **NEAR-TERM** Provide financial support or incentives for low- to no-cost energy audits for small businesses. Key Actors: Non-profits, localities, state agencies
- **VISIONARY** Research mechanisms for local businesses to cost-effectively pursue energy efficiency upgrades in their buildings and operations, including on-bill financing and tax incentives. Key Actors: Localities, state agencies
- **VISIONARY** Explore creative funding opportunities, including working with local lenders and the philanthropic community, for providing zero-interest short term loans for retrofitting and upgrading public housing. Key Actors: Localities, private businesses, state agencies

Energy efficiency and performance tracking programs

- **VISIONARY** Create a voluntary energy performance tracking and annual reporting program for commercial and large multi-family or mixed-use buildings. A recognition program for high-performing buildings could incentivize participation and promote the efforts of participating businesses to the public. Key Actors:
- **NEAR-TERM** Encourage large IT users, such as data centers, educational institutions, and others, to adopt efficient equipment procurement processes, such as [ENERGY STAR IT equipment](#). Key Actors: Private businesses, regional entities, localities, state agencies.
 - For more information on available ENERGY STAR certifications for IT processes and how they can benefit large data users, see Appendix X
- **VISIONARY** Report on the power use effectiveness (PUE) of facilities with dedicated IT infrastructure, such as higher education institutions and research facilities, data centers, and telecommunication facilities. Reporting could be incentivized through a voluntary program or required through local ordinance or state regulation. Key Actors: Private businesses, localities, state agencies.

Outreach and engagement

- **NEAR-TERM** Conduct outreach and educational campaigns on available incentive programs and facilitate connections between building managers and energy audit programs. Key Actors: Localities, regional entities, state agencies, non-profits
- **NEAR-TERM** Partner with community-based organizations and utilities to educate building owners, including non-profits, places of worship, and small businesses on best practices for energy efficiency, as well as any resources and rebate programs from utilities. Key Actors: Non-profits, private businesses, localities, regional entities, state agencies
- **VISIONARY** Facilitate connections between commercial and industrial building energy managers and utilities to conduct energy audits and support knowledge sharing on tangible ways to decrease energy consumption. Key Actors: Localities, private businesses, state agencies
- **NEAR-TERM** Educate customers (e.g., data center operators, institutions, IT departments) on best practices for [servers/IT equipment](#), which can make up a major portion of a building's energy use.

Refer to Appendix X for suggested best practices. Key Actors: Private businesses, localities, regional entities, state agencies.

Possible Output Metrics

Metric
Number of residential buildings that participate in incentive programs and number of type 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 commercial and industrial buildings sector in the region
Number of facilities achieving ENERGY STAR Certification and retaining it year-over-year.
Average PUE of reporting facilities

B4. Encourage the design, construction, and operation of residential, commercial, and industrial buildings above the current required code.



2025-2050 GHG reductions:
0.6 MMTCO₂e

This measure reduces GHG emissions through encouraging the design, construction, and operation of residential, commercial, and industrial buildings above current code requirements. By promoting advanced standards such as passive house design⁴, solar-ready construction, and energy efficiency incentives, the measure aims to significantly reduce building energy use, lower emissions, and enhance comfort and resilience. Supporting above-code development through incentives, recognition, and technical resources helps drive innovation and showcases the benefits of high-performing, sustainable buildings to the broader community. This measure is most appropriate for non-profits, private businesses, utilities, regional entities, and localities.

Measure Goals and Outcomes

Category	Outcome
Energy Use and Cost	Reduced energy use and operating costs

⁴ Passive house design is an extremely high energy efficiency standard achieved through an airtight envelope, efficient use of solar, geothermal heating/cooling, and recovery heat sources. <https://www.eesi.org/articles/view/the-history-of-passive-house-a-global-movement-with-north-american-roots>

Key Actions

- **VISIONARY** Emphasize passive house design in new construction. Key Actors: Private businesses, localities
- **NEAR-TERM** Incentivize solar- and EV-ready development through tax incentives. Research and promote the return on investment (ROI) of developing buildings with these standards. Key Actors: State agencies, localities
- **NEAR-TERM** Leverage density bonuses to incentivize land use patterns that are energy efficient and improve access to high quality affordable housing, Key Actors: Localities
- **NEAR-TERM** Work with local housing authorities to increase efficiency standards amongst their projects.
- **VISIONARY** Under the authority granted by Virginia Code §58.1-3221.2, create a separate property tax class for energy-efficient buildings, including those exceeding the Virginia Uniform Statewide Building Code energy standards by 30% or that meet standards for the Green Globes, LEED, EarthCraft House Program, or federal ENERGY STAR programs. Key Actors: Localities
- **VISIONARY** Support buildings that have already implemented energy efficiency upgrades through initiating and coordinating a voluntary benchmarking and recognition program for new high performing buildings. Key Actors: Localities, non-profits, private business
- **NEAR-TERM** Provide resources to encourage more buildings to track energy usage and implement energy efficiency improvements after commissioning a building. Key Actors: Localities, non-profits, private businesses
 - Publicize high performing buildings (LEED Platinum 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.
 - Provide public tours of high performing buildings to help construction companies, building owners, and other entities to envision future energy efficiency changes
 - Adopt C-PACE, if not already locally adopted, and better promote it to commercial building owners to encourage energy efficiency upgrades in the commercial sector.
- **VISIONARY** Investigate novel or creative options to encourage above-code development. Key Actors: Localities
- **NEAR-TERM** Encourage implementing best practices for cooling & air management of IT equipment including:
 - Free air cooling through air economizers⁵.
 - In-row, overhead, or rear door refrigerant-based heat exchangers.
 - Hot aisle/cold aisle arrangements when air cooling is utilized.
 Key Actors: Private businesses, localities.
- **NEAR-TERM** Encourage onsite energy efficiency improvements of water-cooling systems, including:
 - Raising the chilled water temperature to be only as cold as necessary.
 - Evaluating chillers for upgrades and replacements
 - Utilizing monitoring systems for real-time management and efficiency

⁵ An air economizer is a component of an HVAC system that uses cool outside air to cool a building, reducing the need for mechanical cooling and saving energy. <https://svach.lbl.gov/what-is-an-economizer/>

- **Reviewing operation and efficiency on a regular basis and conducting regular staff training.**
- **During site selection and design, evaluate opportunities to use recycled wastewater and closed-loop cooling systems to minimize impacts on public water supplies.**

Key Actors: Private businesses, localities.

- **NEAR-TERM** Implement best practices for power infrastructure and uninterruptible power supplies (UPS). **Key Actors: Private businesses, localities.**

Possible Output Metrics

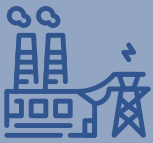
Metric
Number of new buildings that participate in incentive programs and certification level achieve (e.g., LEED or others)
Number of buildings that are all-electric, net zero, or meet passive house standards
Number of participants in any ongoing voluntary benchmarking programs
Number of outreach events and technical assistance materials developed and shared

ENERGY

EMISSIONS OVERVIEW

What resources does Richmond use to meet its electricity demand?

Traditional energy sources



Power plants burn fuels like natural gas to produce energy in the form of steam. The steam spins a generator, which produces electricity.

Burning these fuels releases greenhouse gases, like carbon dioxide.



FOSSIL FUELS

Responsible for **66%** of energy emissions

This category includes fuels like **coal, natural gas, and oil**. Fossil fuels power 9 out of 32 power plants in the Richmond area.



BIOGENIC GASES

Responsible for **34%** of energy emissions

This category includes fuels like **methane** captured from landfills, as well as **biomass**. These fuels power 9 out of 32 power plants in the Richmond area.

Clean energy sources



Clean energy generation uses power from the sun, wind, nuclear fission or dams to spin generators and produce electricity without releasing greenhouse gases.



SOLAR

Powers 13 out of 32 power plants in the Richmond area

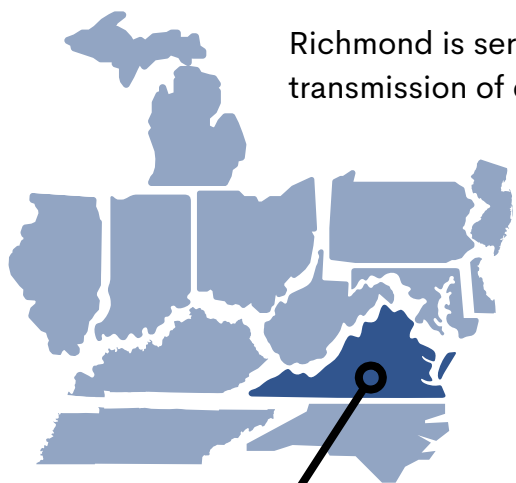


HYDRO

Powers 1 out of 32 power plants in the Richmond area

ENERGY MEASURES

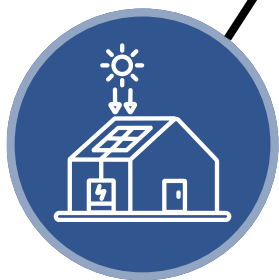
Electricity in the region and at home



Richmond is served by **PJM**, a regional organization that coordinates the transmission of electricity across 13 states and the District of Columbia.

Electricity generated in Richmond can be distributed and consumed in other parts of PJM's region. Similarly, electricity consumed in Richmond can be generated in other parts of PJM's region.

According to the U.S. Energy Information Administration, **Virginia imports more electricity than it exports.**



Clean energy makes up the majority of grid-level electricity generated in Virginia. **52% of electricity generated in the Commonwealth comes from clean energy**; of this 52%, 35% comes from nuclear, 1% from hydropower, and 16% from other renewables like wind and solar.

Clean energy, especially solar, plays an important role **"behind the meter"** as well, generating electricity for individual homes and buildings to help homeowners and small businesses cut costs.

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



Support the adoption of **distributed renewable energy resources**



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

ENERGY

IMPLEMENTATION PARTNERS

ENERGY PARTNERS



SCC regulates investor-owned utilities (IOUs) and some electric cooperatives to ensure utilities provide safe and reliable service at just and reasonable rates and require IOUs to submit integrated resource plans.



DEQ oversees environmental impacts, such as stormwater management and potential effects on wetlands and wildlife. Project developers often need to obtain permits related to these environmental aspects from the state agency.



PJM manages wholesale electricity markets, ensures grid reliability, and manages the interconnection queue for the region.



The Federal Energy Regulatory Commission regulates the transmission and wholesale sale of electricity in interstate commerce.



Dominion Energy is a key electricity provider in the Richmond MSA, a power plant developer, and is subject to VCEA requirements.

E1. Support the adoption of distributed renewable energy resources.



2025-2050 GHG reductions:
3.5 MMTCO₂e

Increasing the deployment of renewable energy is essential for reducing emissions and promoting energy independence. Establishing regional and locality-specific goals for solar megawatt (MW) production provides clear targets for renewable energy adoption, encompassing both distributed and utility-scale solar projects. Streamlining the approval process for solar installations, supporting shared solar that directly benefit communities and minimize land use impacts, and reducing the reliance on fossil fuels can help buffer residents from high electricity costs and improve air quality by reducing pollution from burning fossil fuels. This measure is most appropriate for localities and private businesses.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Resilience	Improved grid resilience
Cost Savings	Lower energy bill costs

Key Actions

Increase community solar adoption

- **NEAR-TERM** Adopt automatic permitting processes, such as SolarApp+. Key Actors: Localities
- **NEAR-TERM** Establish regional-specific goals for solar MW production, both distributed and utility-scale. Key Actors: Regional entities, localities
- **NEAR-TERM** Pursue SolSmart designation at the local and regional levels to reduce the soft costs of solar development. Key Actors: Localities, regional entities
- **NEAR-TERM** Define and implement a pathway for low-to-moderate income (LMI) residents to participate in a community solar program through program design and/or financing support options. Key Actors: Localities, state agencies, private businesses
- **NEAR-TERM** Identify parcels for potential shared solar projects and publish RFIs from solar developers to explore possible rate savings for residents. When shared solar projects are pursued, as much capacity as possible should be allocated to low-income customers. Collaborate with utilities to expand existing programs and/or develop pilot programs to adopt solar ready homes and distributed renewable energy, storage, and peak management. Key Actors: Localities

Reduce fossil fuel use at high energy use facilities

- **NEAR-TERM** Encourage options to reduce emissions from backup power systems, such as replacing diesel generators with natural gas generators. and increase efficiency. Key Actors: Private businesses, localities.

- **VISIONARY** Large battery storage systems to provide on-site backup power are not currently cost-effective at the scale, but in the future technology advancements could make them more attractive options.
- **VISIONARY** Deploy Combined Heat and Power (CHP) systems. Pair CHP plants with fuel cells to realize even greater efficiency. Utilize hydrogen blends and/or pure hydrogen in place of natural gas, if available. For more information on CHP systems and fuel cells, see Appendix X. Key Actors: Private businesses, localities.
- **VISIONARY** Conduct feasibility studies for district energy. Key Actors: Localities, Private businesses.
 - District energy systems can be considered in planning for new commercial and industrial campuses, wastewater treatment facilities, and any other source of waste heat. District energy systems carry hot water or steam through insulated pipes to provide energy or heating for nearby buildings.

Possible Output Metrics

Category	Metric
Solar	Total solar megawatt capacity installed and number of solar installations
Permit Processing	Average permit processing time for solar projects
Community Solar	Number of community solar programs
LMI Participation	Participation rate of LMI households in community solar programs
Renewable Sources	Percentage of electricity from renewable sources

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



This measure supports achievement of the Virginia Clean Economy Act, which is driving the state's electric grid towards a net zero emissions future. A key component of the successful implementation of VCEA is deploying clean energy resources across the state and ensuring a reliable grid throughout the transition. 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. This necessitates collaboration at all levels, with localities supporting resource deployment in a sustainable manner and ensuring their priorities are met (e.g., promoting biodiversity alongside clean energy projects and using under-utilized land for project siting). These efforts will collectively foster a more reliable and sustainable energy system in the Richmond MSA. This measure is most appropriate for state agencies, local governments, non-profits, and regional entities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions from power generation
Resilience	Increased grid resilience and reliability
Land Use Optimization	Utilization of otherwise unusable land

Key Actions

- **NEAR-TERM** Advocate for the Pollinator Smart standards for solar projects to be required at the state level. Incorporate adherence to Pollinator Smart practices into local solar ordinances. Key Actors: non-profits, state agencies
- **VISIONARY** Prioritize solar redevelopment on brownfields, such as closed landfills. Key Actors: non-profits, state agencies
- **NEAR-TERM** Advocate for state-level policies that support clean energy development and adoption while preserving local autonomy. Advocate for expanded local authority over solar requirements.
- **VISIONARY** Study geothermal potential in the region. Key Actors: Private businesses, state agencies,
- **VISIONARY** Improve and accelerate the interconnection process for distributed energy resources (DERs). Key Actors: state agencies
- **NEAR-TERM** Advocate for the continued support of the Virginia Clean Economy Act (VCEA) and to close loopholes in the legislation that allow utilities to avoid meeting portfolio standards. Key Actors: Non-profits
- **NEAR-TERM** Explore Power Purchasing Agreements (PPAs) for municipal energy needs. Key Actors: Localities
- **VISIONARY** Evaluate the potential for district energy systems to recycle waste heat from data centers or wastewater treatment facilities. Key Actors: Localities, private businesses

Possible Output Metrics

Metric
Megawatts of installed grid-scale clean resources in the MSA
State-wide grid carbon intensity

INDUSTRY EMISSIONS OVERVIEW



What are the main sources of industrial emissions in Richmond?



STATIONARY COMBUSTION & ELECTRICITY USE

Responsible for **71%** of buildings emissions

Stationary combustion is the direct use of natural gas to power industrial buildings.



INDUSTRIAL PROCESSES & PRODUCT USE (IPPU)

Responsible for **22%** of industrial emissions

IPPU includes activities that physically or chemically transform materials, such as steel production.



FUGITIVE EMISSIONS

Responsible for **2%** of industrial emissions

Fugitive emissions are unintentional emissions, released due to leaks or equipment malfunctions.



HYDROFLUORO- CARBONS (HFCs)

Responsible for **5%** of industrial emissions.

HFCs are synthetic chemicals widely used as refrigerants and in air conditioning systems. They are potent greenhouse gases.

Spotlight on HFCs



HFCs were first introduced to replace chlorofluorocarbons (CFCs), which were commonly used as refrigerants and found to damage the ozone layer. The **Montreal Protocol** phased out these chemicals in the late 1980s, and in 2016, some countries committed to phasing out HFCs as well.

INDUSTRY MEASURES & PARTNERS

WHAT ARE INDUSTRY'S MAIN SUB-SECTORS?



AMMONIA



IRON & STEEL



PULP & PAPER

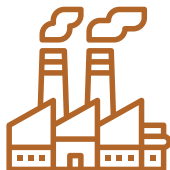


CONSUMER SAFETY
PRODUCTS

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



Support local production and use of low-embodied carbon materials through **clean procurement frameworks**.



Support emissions reductions from **industrial processes**.

INDUSTRY SECTOR PARTNERS



Virginia Energy collaborates with the Governor's office to develop comprehensive energy plans, such as the Virginia Energy Plan, which outlines strategies for achieving a reliable, sustainable, and affordable energy future for all Virginians.



DEQ regulates industrial emissions and can provide technical assistance for the sector.

Hard to decarbonize, the industrial sector includes industry activities such as the processing and manufacturing of physical and chemical materials. The Richmond region includes steel manufacturing, pulp and paper production, chemical, pharmaceutical, and ammonia manufacturing, among other products. 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 that involve chemical reactions that produce emissions that cannot be avoided without changes to chemical processes. Also included in this sector are the Scope 2 emissions from purchased electricity for running industrial buildings (HVAC, lighting, computational processes, and electrical equipment). The measures identified for this sector reflect current technological and policy trends to reduce industrial emissions, including improving process efficiency and fuel switching. It is most appropriate for the private sector and, to a lesser degree, local governments and state agencies.

1.1 Adopt clean procurement frameworks.

Clean procurement frameworks set clear standards for public and private projects, driving demand for sustainable alternatives and fostering innovation in the building sector. Procurement standards require better reporting and documentation, increasing awareness and accountability for the carbon impacts of



materials used. Clean procurement frameworks prioritize building materials with significantly lower carbon footprints. Encouraging the use of locally sourced products such as recycled materials, timber, and low-carbon concretes reduces emissions. This measure not only cuts lifecycle emissions from construction but also supports local economies and advances environmental stewardship by promoting healthier, resource-efficient materials. This measure is most appropriate for localities, private businesses

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced upstream GHG emissions
Supply Chain Transparency	Better reporting and documentation
Market Transformation	Broader adoption of sustainable materials

Key Actions

- NEAR-TERM** Adopt environmentally preferable purchasing (EPP) policies. Implement city-wide procurement guidelines that prioritize products and materials with verified low-embodied carbon content, building on best practices highlighted by the Virginia Department of Environmental Quality. Key Actors: Local governments; private businesses, regional entities, state agencies.
- NEAR-TERM** Leverage local supplier networks by encouraging city agencies and contractors to source building materials from local manufacturers and suppliers, reducing transportation emissions and supporting the regional economy. Key Actors: local governments

- **NEAR-TERM** Set clear procurement standards. Establish minimum requirements or incentives for low-embodied carbon materials in city-funded construction and renovation projects, referencing standards such as Environmental Product Declarations (EPDs) or third-party certifications. Key Actors: Private businesses, local governments
- **VISIONARY** Launch pilot projects in municipal buildings or public works that showcase the use of innovative, low-carbon materials, providing case studies for broader adoption. Key Actors: Local governments
- **VISIONARY** Offer training and resources to local businesses on how to certify, document, and market their low-embodied carbon products to participate in city procurement opportunities. Key Actors: Regional entities, state agencies, local governments, non-profits, private businesses.
- **NEAR-TERM** Involve community members, local businesses, and industry experts in developing and refining procurement frameworks to ensure they are practical, equitable, and effective. Key Actors: Local governments, private businesses, state agencies.

Possible Output Metrics

Metric
Percentage of projects using low-carbon materials
Number of local suppliers certified
Adherence to procurement standards
Share of materials sourced from within the region

I.2. Support emissions reductions from industrial processes.



**2025-2050 GHG reductions:
30.9 MMTCO₂e**

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. High temperature processes are more challenging to electrify. Emissions also come from chemical processes, which may not be able to be altered. Future scientific advancements may find more efficient processes.. Nationally, these areas have been a focus for research and pilot development by federal agencies such as the DOE and EPA. This measure is most appropriate for private businesses, localities, and regional entities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Significant GHG reductions
Clean Air and Water	Achieve cleaner local air and water

Key Actions

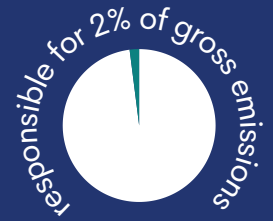
- **VISIONARY** Identify areas with opportunities for multi-use infrastructure, such as integrating industrial hydrogen production with nearby vehicle fueling infrastructure along a trucking corridor (i.e., I-95). Coordinate with local governments and hydrogen developers in other regions of the state to connect markets and alternative fueling networks, thereby maximizing the impact of this and related Measures across the state. This Action is also relevant to the Transportation sector. Key Actors: Regional entities, localities, private businesses.
- **NEAR-TERM** Develop clear regional priorities for continued growth in local manufacturing while prioritizing emissions reductions. Convene engagement sessions with industrial stakeholders and local communities. Key Actors: Regional entities, localities
Key Actors: Regional entities, localities, private businesses.
- **VISIONARY** Assess the need for supporting infrastructure (e.g., pipelines or new transmission) and identify funding opportunities to support key studies (e.g., local geologic sequestration potential). Key Actors: State agencies, regional entities, localities, private businesses
- **VISIONARY** Develop multi-use infrastructure for industrial hydrogen, working with potential major off-takers in the region. . Industrial hubs, such as those in Southside Richmond and Chesterfield, Tri-Cities, and Sussex represent opportunities to deliver electricity generation from alternative fuels to multiple customers. Key Actors: Localities, private businesses

Possible Output Metrics

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

NATURAL & WORKING LANDS EMISSIONS OVERVIEW



What are greenhouse gas sources and sinks?

Sources are processes and systems that *release* carbon dioxide and other greenhouse gases into the atmosphere. Sinks are processes and systems that *sequester and store* carbon dioxide and other greenhouse gases.

Richmond's main **greenhouse gas sources** in this sector are:



LIVESTOCK

Responsible for **49%** of agricultural emissions



AGRICULTURAL SOILS

Responsible for **37%** of agricultural emissions

Emissions from livestock mostly come from **enteric fermentation**, the process by which the digestive system breaks down food. The primary byproduct of this process is methane, a potent greenhouse gas. Preparing agricultural soils can also produce emissions, as carbon dioxide stored in soils is released into the atmosphere through **tilling**.

Richmond's main **greenhouse gas sink**:



FORESTS & URBAN TREES

Responsible for offsetting approximately **5.3 million metric tons** of carbon dioxide yearly, equivalent to **23% of gross emissions**.

5.3 million metric tons of carbon dioxide is equivalent to



1 million passenger cars powered for 1 year



or 700,000 homes powered for 1 year

NATURAL & WORKING LANDS MEASURES

WHAT ARE AGRICULTURE AND FORESTRY'S MAIN SUBSECTORS?



Forestry & Timber Management



Urban Agriculture



Livestock & Crop Production



Land Use Management



Agricultural Markets & Infrastructure



Local Food Markets

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



Remove carbon through **nature-based solutions**, including preserving existing natural working lands and proactively managing land use changes.



Support and incentivize shared land use with renewable energy and agricultural activities (such as **agrivoltaics**).



Expand **urban agriculture** (school/community gardens) and develop region-wide and inter-regional food system distribution.



Increase equitable **tree canopy coverage** and access to public green spaces.



Increase **soil conservation and nutrient management** in agriculture.

NATURAL & WORKING LANDS IMPLEMENTATION PARTNERS

NATURAL & WORKING LANDS PARTNERS



DEQ provides programming, funding opportunities, and technical assistance in conservation and maintenance of natural and working lands.



DOF provides programming, funding opportunities, and technical assistance for forest conservation.



DCR provides programming, funding opportunities, and technical assistance in conservation and maintenance for Virginia's state parks and natural area preserves.

FOOD SYSTEMS PARTNERS



VDACS provides financial and technical assistance for farmers to implement agrivoltaics and other sustainable practices.



VCE provides technical assistance, education, and resources to support urban agriculture and local food production. Offer programs and workshops for farmers and communities.

SOIL CONSERVATION PARTNERS



SWCD promotes soil erosion control measures and provides educational resources for agricultural producers to enhance soil health and increase carbon sequestration across the region.



NRCS provides additional funding and technical assistance for soil conservation initiatives, promoting long-term sustainability of working lands.

NWL1. Remove carbon through nature-based solutions, including preserving existing natural working lands and proactively managing land use changes.



2025-2050 GHG increased sequestration: 23.3

This measure uses land use conservation strategies to remove carbon and support ecological health. It encourages the adoption of sustainable land management practices, the integration of nature-based solutions, and the protection and restoration of natural areas. By focusing on enhancing green infrastructure, supporting healthy forests and habitats, and promoting responsible land stewardship, this measure aims to enhance sequestration, improve environmental health, and build long-term resilience for communities and natural systems. This measure is most appropriate for localities, non-profits and state agencies.

Measure Goals and Outcomes

Category	Outcome
Carbon Sequestration	Increased CO ₂ uptake from managed land area
Stormwater Reduction	Less runoff from facilities with green infrastructure
Wildlife Mobility	Increased biodiversity & wildlife movement in corridors
Water Quality	Improved water quality via riparian buffers & nutrient reduction

Key Actions

Land Use and Planning

- **NEAR-TERM** Retrofit and implement green infrastructure projects at public facilities and municipally owned properties, such as libraries, government buildings, right-of-way, parks and recreation facilities, and schools. Key Actors: Localities
 - The James River Association, in partnership with Richmond Public Library, and the city's Department of Public Utilities, has implemented green infrastructure projects at multiple library branches. These projects include the installation of bioretention basins, trees, and shrubs to manage stormwater runoff. ([source](#))

Forest Management and Habitat Conservation

- **VISIONARY** Install wildlife corridors to preserve habitat connectivity, increase green space, and improve safety. Key Actors: Localities, regional entities, state agencies
 - The DWR Wildlife Corridor Action Plan (WCAP) emphasizes the protection of vital wildlife habitat corridors and the reduction of wildlife-vehicle conflicts. This plan identifies key areas for habitat connectivity, which can guide local efforts in the Richmond area to establish and maintain wildlife corridors.

- **NEAR-TERM** Conserve core habitats and minimize habitat fragmentation to reduce edge effects and support biodiversity. Key Actors: Localities, state agencies, non-profits
- **NEAR-TERM** 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. Key Actors: Localities, state agencies, non-profits
 - Prioritize protections of the identified large ecological cores by Virginia Natural Landscape Assessment's (VaNLA) geospatial analysis.
- **NEAR-TERM** Advocate for the continued support of the Department of Conservation and Recreation (DCR) Agricultural Incentives Program and other state funding for buffer creation, support, and precision nutrient application beyond 2025. Key Actors: State agencies, non-profits, localities, regional entities.
- **NEAR-TERM** Promote agricultural and forestry district programs in localities to support sustainable land use practices. Key Actors: Localities.

Possible Output Metrics

Metric
Number of public facilities retrofitted with green infrastructure
Acreage of land protected or restored for wildlife movement
Number of projects aligned with the DWR Wildlife Corridor Action Plan
Acres of core habitat conserved (VaNLA-based)
Number of localities implementing ag/forestry district programs
Amount of funding secured/distributed via DCR Ag Incentives Program
Acreage of Riparian Protection Areas established or improved

NWL2. Support and incentivize shared land use with renewable energy and agricultural activities.



This measure aims to accelerate the adoption of agrivoltaics - the dual use of land for both agriculture and solar energy production - by addressing regulatory, land use, and educational barriers. The measure supports sustainable land management, renewable energy generation, and resilient food production systems within the region. It is most appropriate for private businesses, localities, and state agencies.

Measure Goals and Outcomes

Category	Outcome
Renewable energy	Reduce GHG emissions from power generation by installing renewable energy
Protect crops	Protect crops from extreme heat stress by shading from solar panels, improving moisture retention

Key Actions

Land Use and Development

- **NEAR-TERM** Clarify zoning practices for agrivoltaics to reduce barriers for farmers while ensuring the protection of agricultural land. Key Actors: Localities
- **VISIONARY** Work with Dominion to discuss multi-use opportunities for land under or parallel to utility rights-of-way. Key Actors: Localities, utilities, private businesses.
- **NEAR-TERM** Integrate Pollinator Smart practices in solar energy projects to enhance biodiversity and support ecosystem health. Key Actors: Localities, private businesses

Farmer Education & Implementation

- **NEAR-TERM** Establish demonstration agrivoltaics projects within the MSA. Organize guided site tours for local producers and decision makers. Key Actors: Private businesses, localities, non-profits.
- **NEAR-TERM** Work with Soil and Water Conservation Districts (SWCDs) to share information about agrivoltaic options and any available grant or financing sources. Key Actors: State agencies, regional entities, localities, non-profits.
- **VISIONARY** Promote agrivoltaics to vineyards and hay producers in the MSA and establish demonstration projects. Key Actors: Regional entities, private businesses

Possible Output Metrics

Metric
Number of municipalities updating zoning codes to accommodate agrivoltaic projects
Number of demonstration agrivoltaic projects established
Acreage of land under agrivoltaic use
Number of farmers receiving agrivoltaic education or technical assistance
Number of pollinator-friendly solar projects implemented
Number of partnerships established with Dominion Energy and other utility companies for multi-use ROW projects

NWL3. Expand urban agriculture and develop region-wide and inter-regional food system



distribution.

This measure focuses on strengthening local and regional food systems by promoting sustainable urban agriculture and improving food distribution networks. This supports economic development, enhances access to fresh and healthy food, and encourages the preservation and productive use of urban land. By fostering collaboration among communities, institutions, and local governments, the measure aims to build a resilient and equitable food system that benefits both urban and rural areas throughout the region. This measure is most appropriate for localities, nonprofits, and regional entities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions by decreasing the need for long-distance food transportation
Economic Development	Strengthen local and regional food systems, developing the local economy

Key Actions

Agricultural & Economic Development

- **NEAR-TERM** Conduct an agriculture/forestry economic study to analyze how local spending is allocated to different aspects of urban tree care and urban agriculture, identifying areas with high return on investment for local spending. Key Actors: Regional entities, localities, non-profits.
- **NEAR-TERM** Support the National Urban Agriculture Initiative in the Richmond MSA. Collaborate with the Small Farm Outreach Program and Virginia Tech's partnership with Virginia State University to advance urban agriculture and sustainable food systems in the region⁶. This initiative aims to build connections between the USDA and urban farmers, offering project evaluation, training, and support to strengthen local food systems and enhance the capacity of urban agriculture in the Richmond MSA. Key Actors: Non-profits, localities, regional entities.

Existing Project Highlight

Virginia Tech and Virginia State University received a USDA grant to lead urban agriculture initiatives in Richmond. The project aims to assess urban agriculture's economic impact, focusing on resource allocation and identifying high-return investment areas

⁶ <https://news.vt.edu/articles/2024/02/cals-urban-agriculture.html>

Land Use and Preservation

- **NEAR-TERM** Support agriculture community land trusts to preserve agricultural land and make it accessible to small or new farmers. Key Actors: Non-profits, localities.
- **NEAR-TERM** Preserve urban agricultural space by exploring the reuse of locality-owned parcels for urban agriculture. Leverage Virginia Tech’s Center for Sustainable Food Systems’ urban agriculture initiative. Collaborate with local municipalities to explore the reuse of vacant or underutilized city-owned parcels for urban farming. This effort aims to enhance local food access, promote sustainable agriculture, and support community-driven agricultural projects. Key Actors: Localities, regional entities, non-profits.

Possible Output Metrics

Metric
Number of schools with on-site garden
Number of Farm-to-School meal programs implemented
Volume of locally sourced food integrated into the school meals

NWL4. Increase equitable tree canopy coverage and access to public green spaces.



2025-2050 GHG increased sequestration: 3.3

This measure aims to expand and protect urban tree canopy across the region by setting clear canopy targets, prioritizing tree planting in areas with limited coverage, and supporting tree preservation and maintenance efforts. By working with local governments, nonprofits, and community groups, the measure seeks to enhance climate resilience, reduce urban heat, improve air quality, and increase carbon sequestration. Programs to assist landowners, incentivize tree care, and train community stewards will help ensure healthy, equitable, and sustainable urban forests that provide lasting environmental and social benefits. This measure is most appropriate for localities and non-profits.

Measure Goals and Outcomes

Category	Outcome
Carbon Sequestration	Increased CO ₂ uptake from urban tree areas
Air Quality	Improved air quality
Biodiversity	Improve wildlife biodiversity through increased habitat
Stormwater Reduction	Increased absorption of stormwater
Public Health	Improved public health and wellbeing due to green space access and reduced impacts of extreme heat.

Key Actions

Urban Trees Expansion

- **NEAR-TERM** Establish local and regional tree canopy cover targets, possibly tailored to different land use types. Key Actors: Regional entities, localities, non-profits.
 - Incorporate and build on the existing tree canopy cover plans, such as Petersburg’s Strategic Tree Canopy Plan and the Richmond 300 Master Plan
- **NEAR-TERM** Develop a regional urban reforestation initiative in partnership with local governments, nonprofits, and community groups to prioritize tree planting in areas with low canopy coverage and high urban heat island effects. Key Actors: Regional entities, localities, non-profits.

Existing Project Highlight

Reforest Richmond: A collaborative campaign aiming to increase the city's urban tree canopy to 60% by 2037, as outlined in the Richmond 300 Master Plan. This initiative focuses on equity-centered, community-driven efforts to enhance green spaces, particularly in underserved

Tree Preservation & Maintenance

- **NEAR-TERM** Create programs to assist private landowners in maintaining and preserving their trees. Offer incentives for tree care and penalties for the removal of healthy trees. Key Actors: Localities.
- **NEAR-TERM** Implement cutting-edge techniques to reduce the costs of maintaining urban trees and enhance carbon sequestration. For instance, use biochar as a soil amendment to boost carbon storage and improve tree health where suitable. Key Actors: Localities, non-profits, private businesses.
- **NEAR-TERM** Develop tree preservation ordinances that provides clear protections for mature trees, requires replacement plantings for removals, and includes penalties for unauthorized tree removal. Key Actors: Localities.
 - The [City of Richmond's Code of Ordinances](#) includes provisions for the maintenance and removal of trees on city-owned property, aiming to protect and manage the urban forest effectively.
- **NEAR-TERM** Establish a certified tree steward program to train volunteers in tree care, maintenance, and community engagement to support urban forestry initiatives. Key Actors: Localities, non-profits.
 - The [Richmond Tree Stewards](#) is a volunteer organization dedicated to promoting healthy urban forests through education and advocacy. Volunteers are trained in tree care and maintenance, playing a vital role in supporting the city's urban forestry programs

Possible Output Metrics

Metric
Number of urban tree canopy cover targets set and adopted by local jurisdictions
Number of trees planted through reforestation initiatives
Number of communities engaged in urban forestry and tree planting efforts
Number of tree preservation and maintenance programs established for private landowners
Acres of land treated with biochar or other soil amendments to enhance tree health
Number of municipalities adopting regional tree preservation ordinances

NWL5. Increase soil conservation and nutrient management practices in agriculture.



2025-2050 GHG reductions:
0.8 MMTCO₂e

This measure focuses on improving soil carbon sequestration and improving environmental health and farm productivity by increasing soil conservating practices and optimizing nutrient use to reduce nitrous oxide (N₂O) emissions. By implementing advanced nutrient management practices and supporting soil-building techniques like cover cropping and improved tillage, the measure aims to increase nitrogen use efficiency, minimize excess fertilizer application, and promote sustainable, resilient farming systems. These strategies help lower emissions, enhance soil productivity, and support long-term agricultural and environmental health.

By encouraging the integration of trees and shrubs into agricultural landscapes, supporting practices such as silvopasture and streamside forest buffers, and advocating for sustained policy and funding support, this measure aims to enhance soil health, reduce erosion, sequester carbon, and protect water quality. These efforts help build more resilient and sustainable farming systems while supporting biodiversity and long-term economic benefits for agricultural communities. This measure is most appropriate for private businesses, regional entities, and state agencies.

Measure Goals and Outcomes

Category	Outcome
Soil Health	Improved soil health, fertility, and organic matter, leading to more productive and resilient agricultural lands
Reduced Erosion	Minimize soil loss from wind and water, protecting valuable topsoil
Carbon Sequestration	Increased carbon sequestration in both soil and vegetation
Long-Term Sustainability	Encourages farming practices that balance productivity with long-term environmental stewardship
Resilience	Help farms withstand climate stresses through improved soil health
Water Quality	Improved water quality via riparian buffers and decreased nitrogen runoff into waterways, which reduces algal blooms
Nitrous Oxide Emissions	Reduce nitrous oxide emissions
Crop Yield	Increased crop yields and crop quality

Key Actions

Agroforestry and Sustainable Land Use

- **VISIONARY** Study the potential for agroforestry in the region to identify opportunities for integrating trees and shrubs into agricultural landscapes for environmental and economic benefits. Key Actors: regional entities, state agencies, non-profits, and private businesses
- **NEAR-TERM** Implement silvopasture practices⁷: Integrate trees into grazing areas to sequester carbon and enhance soil health. Key Actors: Private businesses
- **NEAR-TERM** Establish streamside forest buffers: Plant native trees and shrubs along waterways, maintaining at least a 35-ft buffer. These absorb and runoff, therefore limiting subsequent N2O emissions, preventing erosion, and providing habitat. Key Actors: State agencies, regional entities, private businesses.

Policy and Funding

- **NEAR-TERM** Advocate for the continued support of the DCR Agricultural Incentives Program and other state funding for soil and water conservation practices beyond 2025. Key Actors: State agencies, non-profits, private businesses.
- **VISIONARY** Encourage adoption of Chesapeake Bay Preservation Act (CBPA) requirements beyond the Bay watershed. Key Actors: Non-profits, regional entities.
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Soil Health and Nutrient Management

- **NEAR-TERM** Increase adoption of nutrient management strategies. Nutrient management strategies reduce N2O from agricultural soils by i) enabling better nitrogen use efficiency (NUE) so there is less nitrogen available in the soil for N2O generating processes, and ii) enabling less total nitrogen to be applied due to better NUE. Nutrient management strategies include:
 - Nitrification inhibitors
 - Enhanced efficiency fertilizers
 - Controlled release nitrogen fertilizers
 - Split nitrogen applications to align with nutrient uptake timingKey Actors: State agencies, regional entities, private businesses.
- **NEAR-TERM** Increase the use of cover crops and no- or low-till practices. Cover crops and changes in tillage management practices can also affect soil N2O emissions due to more nitrogen fixation by plants which return nitrogen to the soil and therefore increase nitrogen availability in the soil for future growth cycles. However, both practices predominantly affect soil organic carbon. Cover crops such as rye, clover, or radishes when planted in off-seasons can prevent soil erosion, fix nitrogen, and enhance microbial life. Key Actors: State agencies, regional entities, private businesses.

Existing Project Highlight

The James River Association's Streamside Forests program assists landowners in planting native trees and shrubs along waterways. These riparian buffers, maintained at a minimum of 35 feet, absorb runoff, reduce nitrous oxide emissions, prevent erosion, and provide vital wildlife habitats.

Possible Output Metrics

Metric
Miles of streamside forest buffers planted

⁷ <https://www.cbf.org/issues/agriculture/eight-key-conservation-practices-used-in-regenerative-agriculture.html>

Acres of cropland using cover cropping to prevent erosion

Acres of silvopasture established

Acres of farmland using precision nutrient management

Number of farms adopting no-till or low-till practices

Acres of cropland using cover cropping to reduce erosion and fix nitrogen

NWL6. Support livestock management strategies that reduce emissions.



2025-2050 GHG reductions:
0.4 MMTCO₂e

This measure aims to reduce GHG emissions from livestock operations by improving how manure is handled and by advancing sustainable grazing practices. This measure promotes the adoption of technologies and management approaches such as anaerobic digesters to capture methane, reducing manure storage time, and implementing rotational grazing. These strategies lower emissions of methane and nitrous oxide from manure and pasture systems. By supporting both technological solutions and conservation practices, the measure helps farms generate renewable energy, improve soil and water quality, and build more resilient and sustainable livestock operations. This measure is most appropriate for private businesses, regional entities, and state agencies.

Measure Goals and Outcomes

Category	Outcome
Methane Reduction	Reduction in methane emissions due to livestock operation improvements
Water Quality	Improved water quality by reducing nutrient runoff
Soil Health	Improved soil health due to rotational grazing
Renewable Energy	Renewable energy generation from biogas from anaerobic digester

Key Actions

Manure Management Emissions Reduction

- **NEAR-TERM** Increase adoption of anaerobic digesters to capture methane produced during manure storage. Anaerobic digesters are predominantly relevant for dairy cattle and swine operations that manage manure as a liquid or slurry and collect at a single location. Methane captured can be used as biogas and offset energy needs from other energy sources for farm operations. Key Actors: State agencies, regional entities, private businesses.
- **VISIONARY** Study the applicability of reduced manure storage time strategies in the MSA climate. There are trade-offs between decreased storage time, which minimizes methane production, and

nitrous oxide emissions when manure is spread on soils, but the balance can be favorable in the right conditions. Key Actors: State agencies, regional entities, private businesses.

- Daily spread of manure will result in the highest potential for this mitigation strategy but if manure is stored for longer periods (months), reducing storage time by days to weeks is also beneficial. Decreasing manure storage time is more relevant in warmer climates with favorable land application conditions N2O emissions can increase if manure is applied to agricultural soils so assessment of the GHG synergies and trade-offs is necessary to determine if this is a viable emissions reduction strategy.

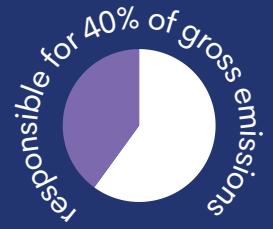
Grazing and Pasture Management

- **NEAR-TERM** Increase the adoption of sustainable grazing practices. Leverage CBF’s [Mountains-to-Bay \(M2B\) Grazing Alliance](#) and continue to advocate for state funding of the Agricultural Incentives Program to support sustainable farming. Key Actors: State agencies, regional entities, private businesses.
 - Promote rotational grazing and related conservation practices
 - Implement forested buffers and livestock stream exclusion 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.

Possible Output Metrics

Metric
Number of methane digesters installed to capture emissions from manure storage
Acres of cropland converted to rotational grazing through M2B Grazing Alliance

TRANSPORTATION EMISSIONS OVERVIEW



What are the main sources of transportation emissions in Richmond?



LIGHT DUTY VEHICLES

Responsible for **52%** of transportation emissions



HEAVY DUTY VEHICLES

Responsible for **30%** of transportation emissions.



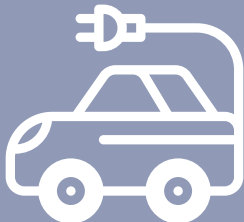
CONSTRUCTION VEHICLES

Responsible for **3%** of transportation emissions



BUSES

Responsible for **1.5%** of transportation emissions.

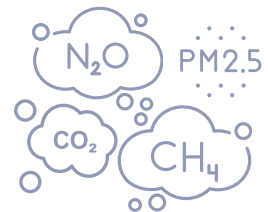


84,936 REGISTERED ELECTRIC VEHICLES

As of September 2024, there are 84,936 registered electric vehicles in Virginia, according to the U.S. Department of Energy.

Air quality impacts from tailpipe emissions

In addition to greenhouse gases, gasoline and diesel vehicles release other pollutants, such as particulate matter, that contribute to poor air quality and smog.



These pollutants can have negative consequences for our communities' health, leading to higher rates of asthma and other illnesses.

TRANSPORTATION MEASURES

WHAT ARE TRANSPORTATION'S MAIN SUB-SECTORS?

And what percentage of emissions are they responsible for?



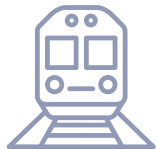
ON- & OFF-ROAD VEHICLES

Responsible for **96%** of transportation emissions



AVIATION

Responsible for **3%** of transportation emissions.



RAIL

Responsible for **0.5%** of transportation emissions



MARINE

Responsible for **0.5%** of transportation emissions.

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



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



Support, incentivize, and provide assistance for the rapid adoption, equitable installation, and use of **zero-emission vehicles**.



Expand equitable **transit** access.



Provide and promote new and expanded opportunities to reduce vehicle miles travelled through **micromobility** options and micro modal infrastructure (e.g., electric bikes and scooters)



Expand use of **low-carbon transportation materials**.

TRANSPORTATION IMPLEMENTATION PARTNERS

STATE PARTNERS



VDOT is responsible for the planning, design, construction, and maintenance of transportation projects across all travel modes.



DRPT funds and regulates transportation projects.



Dominion Energy supports EV infrastructure development through incentive programs and partnerships with state agencies.

LOCAL PLANNING PARTNERS



RRTPO is responsible for planning for the MSA's transportation sector in the near term and long term.



CPDC is a contributing force to planning efforts in eleven member jurisdictions and covers the southern region of the MSA.



CVTPO coordinates with the Richmond MSA on transportation needs and planning.



FAMPO coordinates with the Richmond MSA on transportation needs and planning.

FEDERAL PARTNERS



US DOT (specifically FHWA and FTA) funds and regulates transportation projects.

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



2025-2050 GHG reductions:
2.4 MMTCO₂e

This measure aims to reduce greenhouse gas emissions from port operations by advancing the adoption of low-carbon fuels, electrifying equipment, and implementing operational improvements. The measure modernizes cargo handling, optimizes freight movement, and reduces reliance on diesel trucks. It also supports pilot projects and partnerships to improve efficiency and sustainability throughout the regional supply chain. These efforts will not only help ports meet ambitious emission reduction targets but also improve local air quality, promote public health, and strengthen the resilience of port operations. This measure is most appropriate for regional entities and private businesses.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Operational Efficiency	Improved operational efficiency at ports
Resilience	Enhanced port resilience
Air Quality	Improved air quality

Key Actions

Reduce truck use

- **VISIONARY** Conduct a commodity flow analysis for barge vs truck delivery (more barges will require capital investment at the port to expand capability); storage could also be a limiting factor. Key Actors: Regional entities.
- **NEAR-TERM** Utilize the port to develop sustainability initiatives throughout the region by reducing the number of trucks traveling between Hampton Roads (HR) and Richmond Marine Terminal (RMT), electrifying operations, and making container size changes and barge capacity. Key Actors: Regional entities and private businesses.

Analysis and pilot projects to reduce emissions

- **VISIONARY** Leverage connections with trucking industries to identify areas for incentivizing efficiency improvements and facilitating the adoption of ZEV and hybrid trucks. Key Actors: Private businesses, regional entities.

Possible Output Metrics

Metric
Number of port vehicles transitioned to electric vehicles
Percent reduction in trucks traveling between HR and RMT
Measure change in cargo throughput

T2. Support, incentivize, and provide assistance for the rapid adoption, equitable installation, and use of zero-emission vehicles.



2025-2050 GHG reductions:
32.5 MMTCO₂e

To reduce emissions from the transportation sector, this measure focuses on accelerating the transition to electric vehicles (EVs) and developing a regional, equitable charging network. This measure will be supported through the creation and expansion of a robust charging network, development of incentive programs, workforce development, and other activities to encourage widespread adoption of EVs. Localities may also electrify their municipal fleets and equipment, such as school buses, public works trucks, refuse trucks, and department vehicles. Indirect co-benefits of this project, including improved public health and the creation of clean energy jobs, will spread throughout communities, with a particular emphasis on benefits to overburdened communities. These efforts will reduce transportation-related emissions, improve local air quality, and position the region as a leader in clean mobility innovation. This measure is most appropriate for localities, regional entities, state agencies, and private businesses.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Air Quality	Improved air quality via reduction in internal combustion engine vehicles

Key Actions

EV and EV Charging Infrastructure

- **NEAR-TERM** Develop a pilot project for solar and storage charging for depot sites that may have limited grid capacity, such as school bus depots or municipal fleet depots. Key Actors: Localities
- Look at working for special exemption process for permitting multifamily buildings to add language to include EV chargers.

- **Resources and coordination with utilities on existing grid capacity to identify sites that can integrate EV charging more easily.**
- **NEAR-TERM Promote ZEV and alternative fuel vehicle options in coordination with Virginia Clean Cities; Create a model ZEV procurement policy for fleet managers to adapt. Key Actors: Regional entities, private businesses.**
- **NEAR-TERM Adopt a ZEV procurement plans for municipal fleets, school fleets, and public transportation fleets. Key Actors: Localities.**
- **NEAR-TERM Pursue ChargeSmart designation at the local level to reduce the soft costs of expanding EV infrastructure. Key Actors: Localities.**
- **NEAR-TERM Review permitting process for Electric Vehicle Supply Equipment (EVSE) installation and recommend changes to streamline the process. Key Actors: Localities and regional entities.**
- **NEAR-TERM Develop incentives for commercial properties to install EV charging infrastructure for employees and/or the public. Key Actors: Localities.**
- **NEAR-TERM Collaborate with VDOT to ensure that all rest areas have EV charging infrastructure. Key Actors: State agencies, regional entities, localities.**
- **NEAR-TERM Update the 2013 REVI Plan for the PlanRVA region. Following that model, conduct planning assessments in the Crater region and other non-PlanRVA localities. Key Actors: Regional entities.**
- **VISIONARY Design and develop financial incentive program for income-qualifying households to purchase used EVs.**

Hydrogen refueling network

- **VISIONARY Build out a hydrogen refueling network that can support medium and heavy-duty vehicles. These stations should consider logistical needs for primary users and connect key infrastructure in the region, such as the port, large distribution warehouses, etc. They may also be located near industrial sites that may produce or consume hydrogen in the future to centralize necessary distribution infrastructure. Key Actors: Regional entities, private businesses, localities.**

Possible Output Metrics

Metric
Number of new DC fast chargers installed
Number of ZEVs purchased for public fleets
Number of localities with EV/EV-ready building requirements
Number of localities with streamlined EVSE permitting processes
Number of hydrogen-refueling stations built
Number of businesses that purchase e-bikes for delivery services

T3. Expand equitable transit access.



**2025-2050 GHG reductions:
5.03 MMTCO₂e**

This measure aims to significantly increase public transit use and reduce reliance on single-occupancy vehicles by expanding and enhancing local and regional transit options. By improving service frequency, connectivity, and convenience, especially in key development areas, the measure will make transit the most attractive choice for longer trips. It supports the implementation of new and innovative transit solutions, such as Bus Rapid Transit (BRT), micro-transit, and enhanced rail service, while addressing service gaps and accessibility for all populations. These efforts will lower transportation-related emissions, improve mobility, and support sustainable, equitable growth throughout the region. This measure is most appropriate for localities and regional entities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Air Quality	Improved air quality due to a decrease in vehicle miles travelled
Traffic	Reduced traffic congestion
Smart Growth	Encourages compact, mixed-use development
Mobility and Accessibility	More frequent and connected transit services provide greater access to jobs, education, and essential services, especially for underserved populations

Key Actions

- **NEAR-TERM** Make transit the most convenient mode for longer trips by providing frequent service in and between locally designated development areas consistent with [CoV §15.2-2223.1](#) Key Actors: Localities, regional entities.

Public Local Transit Expansion

- **NEAR-TERM** Implement Bus Rapid Transit (BRT) project to expand the North-South corridor. Key Actors: Regional entities, localities.
- **NEAR-TERM** Expand micro-transit. Micro-transit refers to on-demand public transportation options that utilize dynamic routing and usually serves as a connection to fixed-route public transportation systems or may serve specific populations such as the elderly or people with disabilities. Key Actors: Regional entities.
- **NEAR-TERM** Increase the frequency and availability of public transportation. Expand service to operate seven days per week where feasible, extend weekend service hours, and reduce wait times on existing routes to improve convenience and accessibility for riders. Key Actors: Regional entities.
- **VISIONARY** Improve north-south connectivity within the City and Richmond and between Richmond and Tri-Cities. Key Actors: Regional entities, localities

Strategy Development and Implementation

- **NEAR-TERM** Continue to study how zero-fare policies could benefit GRTC and PAT by increasing ridership and improving equity. Key Actors: Regional entities.
- **NEAR-TERM** Provide subsidies or other incentives to employees who utilize public transit to get to work. Key Actors: Localities, private businesses.
- **NEAR-TERM** Continue to study gaps between micro-transit & current fixed routes. Study how well existing micro-transit and fixed route public transportation systems serve the unique needs of specific populations, including seniors, people with disabilities, youth, and women. Key Actors: Regional entities.
- **NEAR-TERM** Implement Greater Richmond Transit Vision Plan frequent network. Key Actors: Regional entities.
- **NEAR-TERM** Implement RRTPO Park & Ride Strategy lots and expansions. Key Actors: Regional entities, local governments.

Amtrak Service Enhancement

- **VISIONARY** Improve rail service between Richmond and Hampton Roads. Key Actors: Private businesses, regional entities.
- **VISIONARY** Improve frequency and reduce delays between Richmond and DC. Explore ways to reduce travel time and to keep fares low for this high-traffic route. Key Actors: Private businesses, regional entities.
- **NEAR-TERM** Support implementation of the Commonwealth Corridor, which would expand rail service between Blacksburg, Roanoke, Charlottesville, Richmond, Williamsburg, and Hampton Roads. Key Actors: Regional entities, state agencies, localities, private businesses.
- **NEAR-TERM** Modernize rail stations and provide multimodal connections between stations and activity centers. Key Actors: Localities, regional entities.

Possible Output Metrics

Metric
Percentage of residents living within 0.5 miles of a transit stop
Percentage of transit vehicles arriving as scheduled
Number of new transit stops in underserved communities

T4. Reduce vehicle miles traveled through micromobility options and micro modal



infrastructure.

This measure aims to make active and low-emission travel options more accessible and appealing by investing in micromobility and micro-modal infrastructure. Through a coordinated expansion of trails, walkable connections, and neighborhood networks, the measure seeks to make non-car modes of travel

the mainstream choice for short and medium-length trips. By integrating these improvements with transit and regional planning efforts, the measure supports healthier, more connected communities while advancing climate and mobility goals. This measure is most appropriate for localities, regional entities, and non-profits.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Traffic	Decreased traffic congestion
Mobility and Accessibility	Improved micromobility options provide more equitable transport options, especially for underserved populations who may not have personal vehicles
Healthier Communities	Improved physical fitness and reduced stress among the general population

Key Actions

- **VISIONARY** Make active transportation the most convenient mode for shorter trips by completing networks in locally designated development areas consistent with [CoV §15.2-2223.1](#).

Expand Active Transportation

- **NEAR-TERM** Work with communities to identify future bike/ped routes to be incorporated into the plan; connected to the spines under development with Virginia Capital Train & Fall Line Trails. Key Actors: Regional entities, localities, non-profits.
- **NEAR-TERM** Provide subsidies or other incentives to employees who utilize active transportation to get to work. Key Actors: Localities, private businesses.

Promote walkable routes across neighborhoods

- **NEAR-TERM** Map pedestrian networks, especially as they connect to public transportation systems and public green spaces. Identify gaps and prioritize projects to fill gaps. Key Actors: Regional entities, localities, non-profits.
- **NEAR-TERM** Develop walkable routes between neighborhoods and transit stops (accessible sidewalk networks). Key Actors: Localities.
- **NEAR-TERM** Leverage the [Safe Routes to School](#) program to bring investment to improving the availability and safety of active transportation routes to public schools. Key Actors: Localities, non-profits.

Possible Output Metrics

Metric
Miles of new walkable routes constructed
Miles of new trails funded or constructed
Successful implementation of the Fall Line Trail
Number of Active Safe Routes to School Programs

T5. Expand use of low-carbon transportation materials.



This measure advances climate and sustainability goals in the MSA by increasing the use of low-carbon construction materials in transportation projects. Low-carbon transportation materials, also called low-embodied carbon (LEC) materials, include asphalts, concrete, glass, steel and other construction materials that have lower climate impacts throughout their life cycle⁸. Environmental Product Declarations (EPDs) provide transparency on how lifecycle carbon is reduced, through either the inclusion of bio-based or recycled materials and/or more sustainable practices in the production stage. By prioritizing materials such as low-carbon asphalt, concrete, steel, and glass, the measure aims to lower the embodied carbon footprint of new and rehabilitated transportation infrastructure in the MSA. These efforts will support regional decarbonization targets, stimulate local demand for cleaner materials, and help build a more resilient transportation network. This measure is most appropriate for regional entities, state agencies, private businesses, and localities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Infrastructure Durability	Improved durability of infrastructure, with fewer repairs needed over time
Cost Savings	Reduced costs from repair and maintenance

Key Actions

- **NEAR-TERM** Develop procurement policies or incentives to encourage the use of low-carbon materials in transportation projects. Key Actors: Localities, regional entities, state agencies.
- **NEAR-TERM** Use Environmental Product Declarations (EPDs) when evaluating and selecting construction materials to consider the embodied carbon content of infrastructure projects. Key Actors: Localities, state agencies.
- **NEAR-TERM** Provide training and technical assistance to locality staff and project partners on best practices for low-carbon material selection and reporting. Key Actors: Private businesses, localities, state agencies, regional entities.

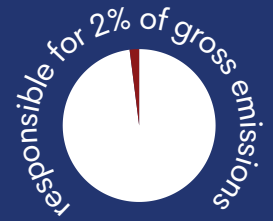
Possible Output Metrics

Metric
Percentage of materials used in transportation projects that are low carbon
Cost savings from using low-carbon materials

⁸ https://www.epa.gov/system/files/documents/2024-11/resources_lecm.pdf

DRAFT

WASTE EMISSIONS OVERVIEW



What are the main sources of waste emissions in Richmond?



SOLID WASTE

Responsible for **96%** of waste emissions



WASTEWATER

Responsible for **4%** of waste emissions.

How does the waste sector emit greenhouse gases?

Methane and other greenhouse gases are released as bacteria break down organic matter in landfills and in wastewater treatment plants. These gases are a natural byproduct of the **decomposition** process.



Methane is an especially potent greenhouse gas. Just a small amount can contribute to a more extreme warming effect, in comparison to other gases like carbon dioxide.

Waste sector co-pollutants



Landfills can contribute to the contamination of water and soils with **heavy metals** like arsenic, lead, and mercury.

Combined sewer systems, that process both stormwater runoff and sewage, can overflow during storms, leading to **raw sewage** entering waterways, posing threats to both humans and ecosystems.



WASTE MEASURES

HOW DOES RICHMOND PLAN TO REDUCE EMISSIONS?



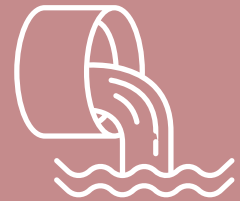
Decrease amount of waste sent to **landfills**.



Support a local **circular economy**.



Support **efficiency upgrades** at wastewater treatment plants.



RICHMOND'S WASTEWATER TREATMENT PLANT

is the largest of its kind in Virginia, with a capacity of 75 million gallons per day and serving 58,000 customers in the region.

WHAT CAN YOU DO TO REDUCE WASTE EMISSIONS?



600,426 TONS OF WASTE were recycled in Richmond in 2020, according to Central Virginia Waste Management Authority, representing approximately 58% of total solid waste.

Plan household meals and **only buy what you need** to avoid food going bad.



Participate in municipal **composting** programs or compost at home.



Learn about **recycling best-practices** to prevent the contamination of waste streams.



WASTE IMPLEMENTATION PARTNERS

WASTE PARTNERS



Virginia Department of Environmental Quality oversees environmental regulations and policies, including those related to waste management, and works with local governments and regional agencies to develop and implement comprehensive waste management plans.



Central Virginia Waste Management Authority is a public service authority responsible for implementing solid waste management and recycling programs in the region.



Richmond's water and wastewater treatment plants are key implementation partners for emissions reductions strategies.



Virginia Department of Professional Occupational Regulations is responsible for licensing for wastewater facilities.

W1. Decrease the amount of waste sent to landfills.



**2025-2050 GHG reductions:
1.7 MMTCO₂e**

This measure aims to significantly decrease landfill-bound waste and greenhouse gas emissions by transforming how the community manages food scraps, recyclables, and other materials. By expanding access to composting, recycling, and hazardous waste programs for residents, businesses, and institutions, the measure supports a circular economy and promotes environmental equity. Financial incentives, updated ordinances, and targeted education will drive behavior change and participation. The measure also seeks to capture and beneficially use landfill gas, set ambitious diversion goals, and pilot zero-waste programs, positioning the region as a leader in sustainable waste management and climate action. This measure is most appropriate for regional entities, localities, and private businesses.

Measure Goals and Outcomes

Category	Outcome
Landfilled Waste	Reduced quantity of waste sent to landfill
GHG Emissions	Lower GHG emissions
Increased Revenue	Increased revenue from recyclable materials and landfill gas

Key Actions

Reduce food waste to landfill

- **NEAR-TERM** Establish an equitable food waste composting program available to all residents either through on-site pickup or convenient drop-off locations. Key Actors: Localities, non-profits.
- **NEAR-TERM** Promote public education on composting at home. Key Actors: Non-profits, regional entities, localities.
- **NEAR-TERM** Make organic/food waste compost, recycling, and yard waste composting available to all businesses. Key Actors: Regional entities, localities, private businesses.
- **NEAR-TERM** Establish on-site composting programs at schools to reduce food waste and educate kids about composting. Key Actors: Localities, non-profits.
- **NEAR-TERM** Support large institutions, like universities, in establishing large-scale composting programs. Key Actors: Private businesses, localities, non-profits.

Provide financial incentives to reduce waste disposal

- **NEAR-TERM** Pass ordinances to impose a tax on plastic bags, phase out polystyrene containers, and ban balloon releases, per state-enabling legislation. Key Actors: Localities.
- **NEAR-TERM** Re-evaluate fees for waste disposal to study how they can better incentivize personal behavior change. Explore alternative structures, such as “pay as you throw” or the option to voluntarily use a smaller curbside trash can for reduced pick-up fees. Key Actors: Regional entities, localities.

Expand recycling programs

- **NEAR-TERM** Require contractors on public projects to divert as much construction and demolition (C&D) waste as possible from landfills. Consider creating a list of recyclable elements that should be

diverted and pilot adhering to it with municipal retrofits/new buildings. Key Actors: Regional entities, localities, private businesses.

- **NEAR-TERM** Identify what C&D materials can be recycled in the region. Explore options for those that are not easily recycled locally, including contracting with recycling facilities outside of the region or attracting private businesses to fill market gaps. Key Actors: Regional entities, localities, private businesses.
- **NEAR-TERM** Expand public curbside recycling to areas not currently served. Where completely infeasible, increase the proximity of drop-off locations to facilitate participation. Key Actors: Localities, regional entities.
- **NEAR-TERM** Mandate that multifamily buildings of a certain size have recycling (and eventually composting) options on-site. Key Actors: Localities.
- **NEAR-TERM** Establish permanent hazardous waste (ex: e-cycle) drop-off locations for residents. Improve public understanding of what can be recycled and where. Key Actors: Regional entities, localities, non-profits, private businesses.
- **NEAR-TERM** Contract with organizations like PCs for People or Tech for Troops to recycle e-waste from localities, school systems, and corporate campuses. These organizations pick up decommissioned electronics, wipe their data, and either refurbish or recycle them, as appropriate. By selling the refurbished components to underserved markets, they help extend tools to those who otherwise would not be able to afford them. Key Actors: Regional entities, localities, non-profits, private businesses.
- **NEAR-TERM** Devise and implement public education campaigns and behavior-change programs to promote recycling and waste reduction. Key Actors: Regional entities, localities, non-profits.

Establish goals for reducing waste

- **NEAR-TERM** Commit to supporting CVWMA's goal of diverting 80% MSW by 2050. Key Actors: Localities, private businesses.
- **NEAR-TERM** Adopt zero waste goals for localities/schools and provide model actions for employees to reduce waste. Key Actors: Localities, regional entities.

Beneficial Use of Landfill Gas

- **NEAR-TERM** Conduct feasibility studies to assess the potential at various landfills for the beneficial use of the collected gas, instead of flaring it. Potential uses could include refining the landfill gas to make Renewable Natural Gas (RNG) or using it to generate electricity. Key Actors: Localities, regional entities, private businesses, state agencies.
 - Explore opportunities to apply for state funding through the Priority Methane Reduction Projects (PMRP) Grant⁹ to support beneficial reuse of captured methane at landfills.

Pilot and scale up zero-waste programs/events

- **NEAR-TERM** Adopt zero waste goals for large public events, such as festivals, conventions, and concerts. Support and incentivize venues to adopt their own zero-waste policies. Key Actors: Localities, private businesses, non-profits.
- **NEAR-TERM** Building on the award-winning pilot project at Henrico Doctor's Hospital, work with hospital systems to recycle non-biohazardous materials. Hospital systems, research institutions, and pharmaceutical developers can also adopt waste management plans and institute procurement practices that reduce waste. Key Actors: Private businesses, regional entities.

⁹ <https://www.deq.virginia.gov/air-energy/climate-pollution-reduction-grant/project-implementation-grants>

Possible Output Metrics

Metric
Percentage of documented recycling and waste disposal information maintained
Number of waste diversion programs created
Number of composting zones established
Percentage of C&D waste diverted from landfills annually
Number of waste reduction educational programs established
Increase in community awareness and participation in waste reduction and recycling initiatives

W2. Support a local, circular economy.



This measure seeks to lay the foundation for a local circular economy by evaluating how plastics, paper, and other materials can be collected and processed by local industries for reuse. Through comprehensive analysis of waste streams, materials flow, and current management practices, the measure will identify opportunities to reduce landfill disposal, recover valuable resources, and support new business models. By partnering with local businesses and exploring innovative reuse and recycling initiatives, the measure aims to strengthen regional manufacturing, reduce emissions, and create a more sustainable, resilient community. This measure is most appropriate for private businesses, regional entities, and localities.

Measure Goals and Outcomes

Category	Outcome
GHG Emissions	Reduced GHG emissions
Landfilled Waste	Less waste sent to landfill
Resource Efficiency	Improved resource efficiency through reuse and recycling
Resilience	Greater supply chain resilience through localized material flows

Key Actions

Conduct comprehensive analysis to assess waste reduction potentials

- **NEAR-TERM** Conduct a comprehensive analysis of waste generation, composition, and management practices across the MSA to identify areas for improvement and opportunities for waste reduction. Key Actors: Regional entities, private businesses.
- **VISIONARY** Study waste flow in and out of the region to better understand the impact of imported and exported waste. Key Actors: Regional entities, private businesses.

- **VISIONARY**

- **NEAR-TERM** Assess current woody material disposal practices and develop initiatives to increase the reuse of woody materials, such as creating mulch, compost, or bioenergy. Key Actors: Localities, regional entities, non-profits

Explore private sector partnerships to enhance local waste reduction efforts

- **NEAR-TERM** Support and participate in re-use and secondary markets such as ReStores, Repair Cafés, the EPA & BCSD Materials Marketplace, Rheaply, or the VDEQ Business Exchange Program Key Actors: Private businesses, localities, non-profits
- **NEAR-TERM** Support efforts to establish a regional circular economy for rare earth minerals. Identify potential locations for hubs where electronics waste could be collected, disassembled, and refined for resale to support local manufacturing and improve the security of critical supply chains of national importance. Key Actors: Private businesses, non-profits, localities, regional entities.
- **NEAR-TERM** Investigate the feasibility and potential impact of container return programs for bottles, cans, and hard plastic containers. Key Actors: Regional entities, localities, state agencies
- **NEAR-TERM** Work with paper and pulp producers to devise improvements to waste management and recycling programs that would ensure cleaner, higher volume recoverable materials stream for their use. Key Actors: Regional entities, private businesses.
- **VISIONARY** Support emerging EV battery recycling market by attracting businesses that will collect and recycle EV batteries in the region. Key Actors: Localities, regional entities, private businesses.
- **NEAR-TERM** Educate and encourage institutions and businesses with large amounts of IT equipment to leverage free IT equipment return and/or recycling programs offered by major IT vendors (HPE, Dell, Oracle, IBM, Cisco, etc.). Key Actors: Private businesses, regional entities, non-profits, localities.

Possible Output Metrics

Metric
List of improvements for waste management of the MSA is created and is updated regularly.
Circular economy tracker developed and frequently updated.
Number of private-public partnerships established for local waste reduction.
Volume of factory waste reduced.

W3. Support efficiency upgrades at wastewater treatment plants.



2025-2050 GHG reductions:
0.04 MMTCO₂e

This measure focuses on improving the operational efficiency and sustainability of wastewater treatment plants (WWTPs) by targeting energy use and resource recovery. Through comprehensive energy audits, strategic retrofits, and the adoption of smart technologies, the measure aims to reduce energy consumption and operating costs. Additionally, it advances the capture and conversion of waste gases into renewable energy, supporting a transition toward self-sufficient and climate-friendly

wastewater operations. Pilot programs and feasibility studies will further explore innovative solutions, such as biogas production, to maximize environmental and economic benefits for the region. This measure is most appropriate for localities.

Measure Goals and Outcomes

Category	Outcome
Energy Consumption	Lower energy consumption from WWTPs
GHG Emissions	Reduced GHG Emissions
Air Quality	Improved air quality through capture of waste gas

Key Actions

Conduct Energy Audits and Upgrades

- **NEAR-TERM** Complete energy audits on all facilities, identifying opportunities for energy retrofits across its facility portfolio, and integrate findings into capital improvement planning. Key Actors: Localities.
- **NEAR-TERM** 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. Key Actors: Localities.
- **VISIONARY** Implement Smart Technology Upgrades. Some upgrades that could be implemented in regional facilities include advanced monitoring systems, automated controls, and energy-efficient machinery. Key Actors: Localities.

Capture and Convert Waste Gases

- **VISIONARY** 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. Key Actors: Localities.

Possible Output Metrics

Metric
A WWTPs program developed (Y/N)
Reduction in operational costs due to energy savings
Enhanced monitoring and control of wastewater treatment processes
Increased energy efficiency of wastewater treatment plants
Number of energy audits conducted and resulting amount of energy savings potential and upgrades identified

Co-Benefits Analysis



Co-Benefits

In addition to greenhouse gases, other air pollutants such as criteria air pollutants (CAPs) and hazardous air pollutants (HAPs) pose significant risks to public health and the environment. Tracking these pollutants over time helps identify what is being emitted, in what quantities, and from which sources. CAPs include ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead, while HAPs—also known as air toxics—encompass over 180 harmful chemicals such as benzene and mercury. Related pollutants like volatile organic compounds (VOCs) and ammonia (NH₃) are also important to monitor, as they contribute to or form these pollutants through chemical reactions in the atmosphere.

Key Findings

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 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 the Appendix. Table 4 and Table 5 show the cumulative reductions by pollutants and sectors. Table 6 then presents the monetized health benefits from improved public health due to the lower co-pollutant emissions.

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 directly linked to clear public health benefits and regulatory air quality standards, supported by well-established emissions factors and monitoring methods. 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.

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 electric vehicles are used and vehicle miles traveled 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.¹⁰

In addition to health benefits from air pollution removals, the natural and working 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

¹⁰ <https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/buildings>

avoided runoff benefits reaching over \$34,226,505 million/yr. The results of the air pollutant removals are included in Table 4.

Table 3. Cumulative Changes in Co-Pollutant Emissions (MT) by Pollutant, 2025-2050

Pollutant	Cumulative Reductions from Change in Energy Use	Removals from NWL
NOx	35,840	35,218
SO ₂	38,690	20,585
PM	21,324	73,548
CO	24,299	5,945
Lead	0.46	35,218

Table 4. Cumulative Co-Pollutant Reductions (MT) by Pollutant and Sector, 2025-2050

Sector	Pollutant	Cumulative Reductions (MT) (2025-2050)
Waste	NOx	39.85
Residential/Commercial Buildings	NOx	32,023.58
Industrial Buildings	NOx	-868.00
On-Road	NOx	2,201.56
Off-Road	NOx	2,443.20
Residential/Commercial Buildings	SO ₂	1,476.88
Industrial Buildings	SO ₂	21,841.76
On-Road	SO ₂	49.43
Off-Road	SO ₂	930.53
Waste	PM	16.94
Residential/Commercial Buildings	PM	2,498.70
Industrial Buildings	PM	18,398.47
On-Road	PM	71.76
Off-Road	PM	337.66
Waste	CO	747.18
Residential/Commercial Buildings	CO	18,180.36
Industrial Buildings	CO	-2,541.09
On-Road	CO	20,336.14
Off-Road	CO	1,967.58

Sector	Pollutant	Cumulative Reductions (MT) (2025-2050)
Residential/Commercial Buildings	Lead	0.40
Industrial Buildings	Lead	0.05

Note: Lead could not be calculated for all sectors; Negative reductions = emission increase

Health impact estimates, derived from COBRA, include both incidence counts and monetized benefits across categories such as mortality, hospital visits, restricted activity days, and respiratory/cardiovascular conditions. These are presented in Table 4 below. COBRA is a screening tool developed by the 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., PM2.5, SO₂, NOX, VOCs) on public health outcomes and monetizes these benefits using peer-reviewed concentration-response functions and economic valuation methods.

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	\$10,802	740
Hospital Visits	\$11.5	1,656
Missed School/Work or Restricted Activity	\$318	639,547
Cardiovascular Conditions	\$31.8	389
Respiratory Conditions	\$329	502,020

Workforce Assessment



Workforce Analysis

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.

This workforce analysis provides information to help the region proactively plan for future workforce needs. The CCAP is projected to impact nearly 60 different occupations ranging from bus drivers to construction and skilled trades. In total, these occupations represent roughly 82,500 jobs or 11.2% of total jobs in the MSA.

The workforce gap analysis uses data on projected growth (the number of workers needed to fill new growth), separations (employees leaving the workforce/occupation), and hires to estimate the shortage or surplus of workers for each of the 60 occupations. The workforce gap analysis only considers existing conditions in the labor market and does not factor in additional demand for workers that implementing the measures could generate.

Key Findings

Currently, Richmond MSA's labor market is well balanced without critical gaps. The analysis indicates that occupations with estimated shortages include Heavy Tractor-Trailer Truck Drivers, Construction Laborers, Carpenters, and First-Line Supervisors of Construction in the buildings sector and Miscellaneous Assemblers and Fabricators and Chemical Equipment Operators in the industry sector. The workforce shortages in these occupations are minor (less than 2% of all workers in the occupation), except for Chemical Equipment Operators where it represents 2.7% of all workers in the MSA for that occupation.

In contrast, workforce surpluses in the region for the CCAP occupations are relatively more prominent. Laborers and Freight, Stock, and Material Movers is estimated to have the largest surplus, 636 workers or 5.5% of the total workforce in that occupation. Surpluses also are estimated for Light Truck Drivers, Supervisors or Transportation and Material Moving Workers, Electricians, Landscaping Workers, and Civil Engineers.

Although the current labor market has minor gaps, the analysis indicates that these gaps can potentially be exacerbated with CCAP implementation. For instance, the current largest shortage of workers in the MSA is 220 for Heavy Tractor-Trailer Truck Drivers, which represents almost 2% of the total number of workers in the occupation in the MSA. Heavy Tractor-Trailer Truck Drivers are vital to implementing measures within the waste sector and the labor shortage could pose challenges in the near future. Since many of the workforce overages and the greatest workforce shortage are in the transportation sector it is a great opportunity to utilize transferable skills to fill gaps. Creating pathways for professional development within sectors makes it easier individuals pivot careers and fill necessary vacancies.

Table 6. Occupations with Largest Workforce Shortages 2025

SOC Code	Occupation	Relevant Sector	Potential Workforce Shortage	Potential Shortage as % of Total Employment
53-3032	Heavy and Tractor-Trailer Truck Drivers	Waste	-219	1.9%
47-2061	Construction Laborers	Buildings	-32	0.5%
51-2098	Miscellaneous Assemblers and Fabricators	Industry	-31	1.2%
51-9011	Chemical Equipment Operators and Tenders	Industry	-13	2.7%
47-2031	Carpenters	Industry, Buildings	-12	0.3%
47-1011	First-Line Supervisors of Construction Trades and Extraction Workers	Transportation, Buildings	-10	0.2%

Table 7. Occupations with Largest Workforce Surplus 2025

SOC Code	Occupation	Relevant Sector	Potential Workforce Shortage	Potential Shortage as % of Total Employment
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	Transportation	636	5.5%
53-3033	Light Truck Drivers	AFLOU	185	3.4%
53-1047	First-Line Supervisors of Transportation and Material Moving Workers, Except Aircraft Cargo Handling Supervisors	Transportation	70	2.3%
47-2111	Electricians	AFOLU, Transportation, Buildings, Energy	64	1.7%
37-3011	Landscaping and Groundskeeping Workers	AFLOU	57	1.0%
17-2051	Civil Engineers	Buildings	56	2.4%

Addressing Workforce Shortages and Surpluses for CCAP Measures

Addressing these shortages will ensure successful implementation of the CCAP, and it is important to plan for these gaps by expanding early education career programs, providing technical training, and offering mentorship.

Upskilling and Reskilling

Developing training for workers to reskill and upskill can be the most immediate solution to address potential workforce shortage. The most immediate solution to address these imbalances is to reskill and upskill workers from occupations where there are surpluses to occupations with shortages. Bridging these gaps provides opportunities for workers in surplus professions to develop professionally and work in areas projected to grow through CCAP implementation. Switching careers can also provide community members with access to higher paying jobs and increased opportunities for career growth. Some examples of careers with transferable skills that could address workforce gaps include:

- **Laborers and Freight, Stock, and Material Movers where there is a relatively large surplus of workers who can be reskilled for Construction Laborers, where there are shortages.**
- **Reskilling Light Truck Drivers for Heavy and Tractor-Trailers.**
- **Matching skills within sectors can ensure that these transitions can be made with little additional training.**

Training building automation design professionals would also help accelerate CCAP implementation. One shortage emphasized within the workforce survey was the need for more building automation design professionals. These are the individuals who create automated systems such as HVAC, lighting, and energy management in buildings. This is an example of a gap that will be further exacerbated by CCAP implementation if not addressed. It is crucial to pinpoint these gaps early on to prepare the workforce and mitigate project delays.

Workforce Partners and Training Resources

In the medium to long term, creating a support network of partners, educational institutions, training providers, and government agencies will help support career transitions and holistic solutions to CCAP implementation. Apprenticeships, reskilling opportunities, and flexible certification pathways can help ensure a steady pipeline of qualified workers for CCAP execution.

Within the Richmond MSA there are a range of training (based out of community colleges or privately organized) and apprentice programs for EV, heat pump, electrical, and HVAC installation and maintenance, construction, energy auditing, farming, landscaping, operating buses and heavy tractor trailers.

Early Career Professional Development

It is important to introduce career opportunities with shortages to high schoolers and young professionals. Henrico County schools, Goochland High School, Dinwiddie High School, Powhatan High School, and Sussex Central High School all have career training opportunities ranging from electrical to landscaping and more general career exploration opportunities. It will be crucial to maintain open lines of communication with professional development programs in schools to fill workforce gaps and provide steady jobs to graduates.

Ultimately, addressing workforce shortages and surpluses is central to the success of CCAP and supporting the Richmond MSA community members. By anticipating labor market trends, investing in workforce development, and embracing innovative workforce solutions, the region can secure the expertise needed for the CCAP. Adequately evaluating these workforce imbalances is beneficial to ensuring that the CCAP measures can be implemented but also provides workers with opportunities to develop new skills, pivot careers, and implement vital climate action. It is important to note that at this time many employers and businesses are experiencing uncertainty due to changes in the federal landscape, so planning and coordination are exceedingly important to ensure jobs are available.

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